

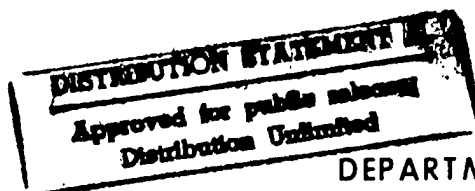
EVALUATION OF THE
VEHICLE OUT-OF-COMMISSION STANDARD
FOR AIR FORCE VEHICLE MAINTENANCE UNITS

THESIS

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Captain, USAF

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AFIT/GTM/LSM/95S-2



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DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GTM/LSM/95S-2

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EVALUATION OF THE VEHICLE OUT-OF-COMMISSION
STANDARD FOR AIR FORCE VEHICLE MAINTENANCE UNITS

THESIS

Presented to the Faculty of the School of
Logistics and Acquisition Management
of the Air Force Institute of Technology

Air University

in Partial Fulfillment of the Requirements for the
Degree of Master of Science in Logistics Management

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September 1995

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Acknowledgments

We would like to thank Dr. David K. Vaughan and Lt. Col. Floyd R. Anible, our thesis advisors, for their guidance and support throughout this research effort. Dr. Vaughan's expertise in the area of research development and Lt. Col. Anible's vast amount of transportation experience led to a successful completion of this project. Together, they provided valuable insights into our thesis project. We would also like to thank Dr. Guy S. Shane and Dr. Panna B. Nagarsenker for their assistance with the statistical analysis of our survey data. Their expertise in statistical procedures and willingness to share their knowledge was invaluable to this research. We would also like to thank Lt. Col. Hoeft, HQ PACAF/LGT, for sponsoring this project.

Finally, we would like to make a special acknowledgment to our wives. Without their unending support and understanding throughout this endeavor, this research effort would have been nearly impossible.

Captain Lawrence F. Audet, Jr.

Captain Christopher K. Arzberger

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Abstract

The usefulness of the vehicle out-of-commission (VOC) performance standard currently utilized by the United States Air Force (USAF) to compare vehicle maintenance units is evaluated in this paper. Because the Department of Defense is facing budget and manpower reductions, the importance of productivity, efficiency, and effectiveness in daily operations is being stressed. Unfortunately, the VOC performance measure does not adequately apply these concepts. By examining the concepts of productivity, efficiency, and effectiveness, the inadequacy of the VOC measure is highlighted. In addition to comparing VOC to these concepts, the VOC measure is compared to the essential characteristics of an effective performance measurement system. A review of research into performance measurement is conducted, with emphasis on USAF transportation squadrons, to examine perceptions about the VOC measure. Because the VOC measure is viewed as inadequate, a review of performance measurement indicators throughout the government is analyzed to determine the type of performance measurement system that should be used for vehicle maintenance units. The use of linear regression is advocated.

This research also identifies the seven independent factors perceived by transportation officers as impacting the performance of vehicle maintenance the most. These factors include training levels of assigned personnel, parts availability, available manpower, budget available for vehicle maintenance, tool and equipment availability, age of vehicle fleet, and experience (# of years) of assigned personnel and should be included in a

regression model to accurately establish and compare the performance levels of vehicle maintenance units.

EVALUATION OF THE VEHICLE OUT-OF-COMMISSION STANDARD FOR AIR FORCE VEHICLE MAINTENANCE UNITS

I. Introduction

Background

In a profit organization, management effectiveness and efficiency is usually based on a measure of profit such as return-on-investment or earnings-per-share. In nonprofit organizations, like the Department of Defense (DOD), the goal is to achieve socially desired nonfinancial objectives (Todd and Ramanathan, 1994:123). Usually the goal is to provide services (Keating and Keating, 1981:40). Because there is no profit measurement, nonprofit organizations are forced to use hard-to-quantify management effectiveness indicators (D'Angelo, 1992:1-2). In nonprofit organizations, there is no single criterion for resource allocation, cost/benefit analysis is difficult, managerial performance is hard to cross-compare, decision-making is centralized, and it is difficult to cross-compare subordinate units (Anthony and Herzlinger, 1980:40-41).

When a decision is made about resource allocation, the effect on the "bottom line" (profit) provides a common basis for evaluating alternative uses of resources. In nonprofit organizations, the objectives of the organization have nothing to do with profit and thus a comparable evaluation is impossible (D'Angelo, 1992:7). There are many different types of well tested cost/benefit analysis techniques that profit organizations can use when

comparing different proposals in determining which proposal generates the most profit. With no profit measure in nonprofit organizations, it is hard to quantify the benefits of competing proposals. Evaluating managerial performance in a profit organization is linked to decisions the manager makes in an attempt to increase profit, and this profit measure provides a common thread to evaluate and compare managers throughout the organization. Managers in nonprofit organizations strive to stay within budget limits and sometimes are forced to accept decreased quality and customer service levels in accomplishing the mission. Decision-making in the profit organization can be decentralized because managers are aware that any action taken should support the objective of profit. Without a single, all encompassing objective such as profit, decision-making in the nonprofit organization is often centralized to ensure the diverse goals and objectives of the organization are met (D'Angelo, 1992:7).

For nonprofit organizations there is no measure of output that compares with the effectiveness of profit measures available in profit-seeking firms (Keating and Keating, 1981:43). This inherent nature of military organizations, where management decisions are based on available resources, makes productivity difficult to measure (Anthony and Herzlinger, 1980:5). Increased economic constraints are forcing the DOD to operate with emphasis on the effective and efficient utilization of allocated resources to produce goods and services, and inadequate performance measures are hindering this effort.

As Congress continues to reduce the DOD's budget and force size, the challenge to the military manager is to do more with less. The Air Force's obligation authority is expected

to grow by \$500 million, but real growth will shrink by 2.1 percent in fiscal year 1995 (Fulghum, 1994:24). The force structure will be cut by 10-15 percent in fiscal year 1995 and the number of flying wings will be reduced from 20 to 17 by 1999 (Fulghum, 1994a:25). As a result, Air Force managers face reduced operating budgets and decreased manning levels. To make efficient and effective use of limited resources, managers must have adequate performance indicators to aid in the decision-making process. Reductions in the Air Force are not unlike those currently experienced in civilian industry.

Many senior executives in a multitude of industries have had to rethink how they measure performance. For example, at Edmonton Telephone Corporation, increased competition, new technology, and increased customer service levels have forced management to implement new performance measurement systems (Meadows and others, 1994:17). Because private industry and the Air Force have recently adopted new management approaches, like Total Quality Management, both organizations have realized that if you change management strategy, your measurement system should also change to be consistent with this new strategy (Kaplan, 1993:144).

The emphasis on effective and efficient use of resources was highlighted by the 1993 Government Performance and Results Act, which evaluated strategic planning and performance measurement in the government. This act emphasized improving federal program effectiveness by focusing on results, quality, and customer satisfaction (Duquette and Stowe, 1993:29). In addition, a Majority Staff, House Committee report on government operations, entitled "Managing the Federal Government - A Decade of

Decline," mandates government efficiency and effectiveness. To further emphasize the government's commitment in this area, President Clinton submitted a report to Congress, entitled "Vision of Change for America." This report calls for a shift to what he calls "entrepreneurial government" intended to make the government more efficient and effective by abandoning practices that impede flexibility and waste resources (Duquette and Stowe, 1993:48).

Effectiveness and efficiency are directly related to productivity. Mali defines productivity as "the measure of how well resources are brought together in organizations and utilized for accomplishing a set of results. Productivity is reaching the highest level of performance with the least expenditure of resources." He also states that "productivity is a combination of effectiveness and efficiency." A study of the federal government conducted by the Civil Service Commission, the General Accounting Office, and the Office of Management and Budget and Audit has stressed the importance of this definition and its applicability to government organizations (Mali, 1978:83). Realizing the importance of efficiency as early as 1968, the Air Force began developing information management systems to aid with measurement of various transportation functions.

Transportation Measurement

In 1968, the Air Force established a computerized information system, known as the Transportation Integrated Management System (TRIMS). The system was designed to create a data base capable of interfacing with other functional areas within transportation

for on-line data retrieval (Directorate of Transportation, 1968: I-1 - I-5). This program was never fully established and the Vehicle Integrated Management System (VIMS), a subsystem of TRIMS, was established in 1970. This system was designed to provide data to improve management reports and enable managers to resolve vehicle management problems using accurate information (Directorate of Transportation, 1969:10-11). In addition, performance indicators were established as part of VIMS to help analyze and compare performance levels of vehicle maintenance units. The primary indicator of performance for vehicle maintenance units is the vehicle out-of-commission (VOC) rate. It is a combination of the number of hours a vehicle is deadlined for maintenance and parts. Vehicles deadlined for-parts (VDP) are those that are placed out of service due to nonavailability of parts. Vehicles deadlined for-maintenance (VDM) are vehicles placed in an awaiting maintenance status. Figure 1 graphically portrays the relationship between VDM, VDP, and VOC. VOC is the overall measure of support given to its customers (Department of the Air Force, 1994:3).

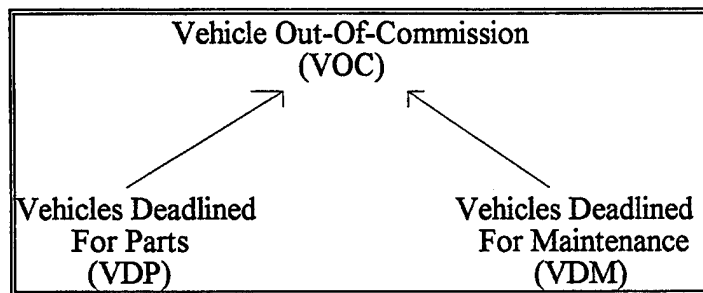


Figure 1. VOC Components

According to AFM 77-310 Vol. II, the VOC standard for all bases is 10 percent (Department of the Air Force, 1987:12). Table 1 shows how VOC rates, by base, are reported to HQ AFMC and Figure 2 graphically illustrates VOC by base. Although Air Force regulations divide VOC rates into VDP and VDM, AFMC has recognized the importance of budget levels available for vehicle maintenance units and has created another category called vehicle deadlined for funds (VDF) (Moon, 1995a).

Table 1. Components of the VOC Rate (Moon, 1995)

	AFMC BASES										
	A	B	C	D	E	F	G	H	I	J	K
VDM	4	10.4	6.1	4.7	4	3.5	4.9	3	3	4.4	3.2
VDP	0.2	2.6	1.5	1.9	0.2	1.4	1.6	2	0.2	0.8	0.7
VDF	0	0	0	0.7	0	0	0	0	0	0	0
VOC	4.2	13	7.6	7.3	4.2	4.9	6.5	5	3.2	5.2	3.9

By examining this performance measurement report, managers are not able to determine the underlying reasons for particular VDM, VDP, or VDF figures. As a result, the VOC standard does not aid the decision-making process. Although this performance indicator was developed over twenty years ago, it is still considered to be the primary means of evaluating performance of vehicle maintenance units throughout the Air Force. However, this indicator does not account for differences in operating factors that impact performance levels of vehicle maintenance units such as unit manpower levels, age of the

vehicle fleet, size and age of maintenance facility, budget level, training level of personnel, and parts availability.

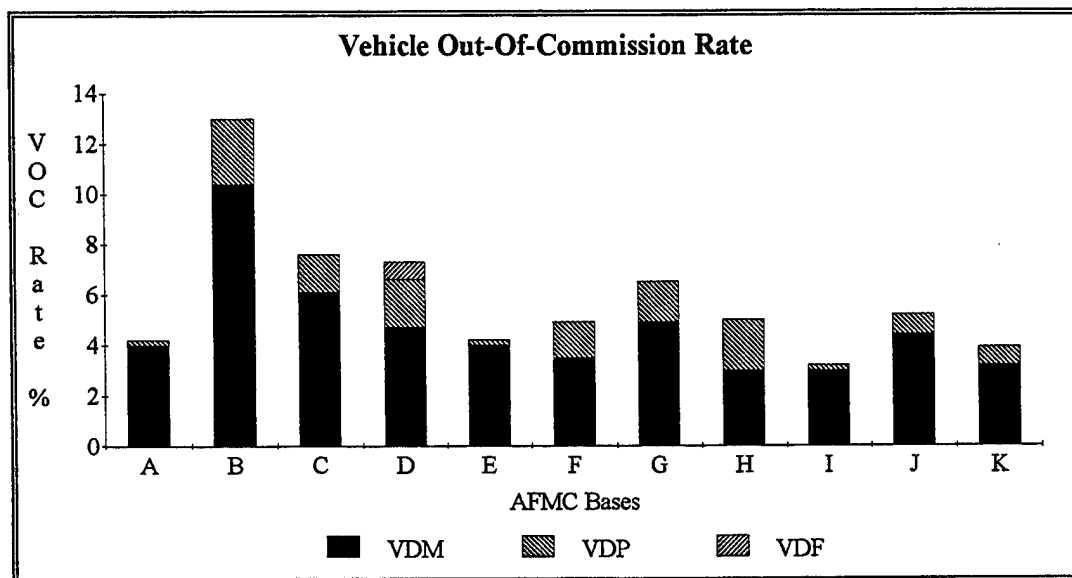


Figure 2. VOC Rate Depicted Graphically (Moon, 1995).

Status of VOC Measurement

Research conducted in 1989 by 1LT Kevin N. Brewer on Perceptions of Air Force Base-Level Transportation Officers Towards The Effectiveness of Air Force Base-Level Transportation Performance Measurement Indicators showed substantial dissatisfaction with current measurement indicators among transportation officers at all levels. This research pointed out that independent variables such as manpower, environment, and budget were not considered when measuring performance and that, as a result, cross-comparison of units should not be performed (Brewer, 1989:95).

Comparison of units using VOC measurements is not accurate and Brewer concluded it should not be used to cross-compare units. However, it is used habitually by the Air Force in rating the performance of its vehicle maintenance units. Air Force managers should not make the same mistake made with numerous other management tools and assume this performance measure is valid for all situations. Different measures should be utilized “according to the reasons for which they were developed” (Flynn, 986:393).

VOC was developed to measure customer satisfaction, but has developed into a global indicator of vehicle maintenance performance. The recent adoption of the Total Quality (TQ) philosophy towards management within the Air Force resulted in a change in strategy that should be linked with performance measures. However, the VOC performance measure established in 1970 does not lend itself to the TQ philosophy being used today. The performance measure should change with the strategy and keeping the same measure in place for years should be avoided (Schmenner, 1993:524).

Specific Problem Statement

The current vehicle out-of-commission standard is not indicative of how a vehicle maintenance unit is performing and can not be used to effectively cross-compare units.

Research Question

Determining the best measure of efficiency, effectiveness and productivity for Air Force vehicle maintenance units that will allow accurate cross-comparison of these units is

the main goal of this research. The research question, therefore, is “what is the most appropriate performance measurement system for Air Force vehicle maintenance units?”

Investigative Questions

The primary investigative questions that need to be answered are:

1. How are efficiency, effectiveness, and productivity related to performance measurement?
2. Why are more relevant performance measurement indicators needed in government organizations?
3. How do vehicle maintenance officers perceive the VOC performance standard?
4. Should independent factors be included when establishing a performance standard?
5. Is multiple regression analysis suitable for evaluating the performance of vehicle maintenance units?
6. What independent variables impact the performance of vehicle maintenance units the most?
7. Are there differences in perceptions, based on rank, transportation experience, and current position, about the VOC standard?
8. Are there differences in perceptions, based on rank, transportation experience, and current position, about the most important independent variables impacting vehicle maintenance performance?

Scope

This research evaluates the vehicle out-of-commission standard used by management to analyze and compare performance of vehicle maintenance units. This research is limited to vehicle maintenance units in the USAF. Independent variables that impact the performance of vehicle maintenance units the most will be identified by transportation experts.

Summary of Ideas Presented

In this section we described the differences in determining management effectiveness in profit and nonprofit organizations. We also highlighted the problems facing the DOD in terms of budget and manpower reductions. These constraints have forced government organizations to emphasize the importance of efficiency, effectiveness, and productivity in daily operations. Unfortunately, current performance measures of vehicle maintenance units do not adequately apply for these concepts. The specific problem is that current vehicle out-of-commission standards are not indicative of how a vehicle maintenance unit is performing and can not be used to effectively cross-compare units. To address this problem, this research will attempt to determine the best measure of efficiency, effectiveness and productivity for Air Force vehicle maintenance units that will also allow accurate cross-comparison.

The literature review in chapter two will answer investigative questions one, two and five. The relationships between performance measurement and the essential characteristics of productivity, effectiveness, and efficiency will be examined. This review will evaluate the need for more relevant performance measurement indicators in Air Force organizations and suggest a performance measurement system that could be used by vehicle maintenance units.

II. Literature Review

Introduction

This literature review examines relevant information about the components of a good performance measurement system. Additionally, the concepts of productivity, efficiency, and effectiveness and how they are related to performance measurement will be examined. Next, a review of previous research into performance measurement will be conducted, with emphasis on USAF transportation squadrons, to examine perceptions about the VOC standard. Finally, performance measurement indicators throughout the government will be analyzed to determine the type of performance measurement system that should be used for vehicle maintenance units.

Performance Measurement

Performance measurement is more than a simple measure of output. The primary goal of a performance measurement system is to create meaningful data that can be used to aid the decision-making process. Other important goals of an effective performance measurement system include improving resource allocation, fostering fact-based management, and providing evidence of success or failure (Ghobadian and Ashworth, 1994:49). Performance measures allow managers to assess outputs in relation to meeting organizational objectives (Pollitt, 1986:315).

Past measurement systems provided detailed information that was rearward looking and forced the manager to be reactive instead of proactive. Such is the case with the VOC measure. For example, a rating of 11% reflects the number of vehicles that are out of service at a given period of time or for a given period of time. When vehicle maintenance officers want to know the factors contributing to this rating, additional research must be conducted. Determining the factors underlying this rating can be a difficult and time consuming task and on many occasions there is not enough time available to conduct the research to aid the decision-making process. The ideal performance measurement system would provide information pertaining to the factors causing the 11% VOC rate and allow the manager to make timely changes to correct the situation. For example, a lack of training could be a cause of an unacceptable VOC rate. Scheduling classes that provide instruction on how to repair vehicles quickly and efficiently could solve this problem. For managers to act in this proactive manner, the performance measurement system must be able to provide relevant information before the decision has to be made. Therefore, the system must be designed to provide pertinent and timely information (Ellis, 1993:16).

Government agencies recognized for high achievement use their measurement systems to aid in decision-making. These types of measurement systems are designed to answer the following questions: Is the organization performing its job? Is it responsive? Is it productive (Holzer and Callahan, 1993:331)? Is the organization achieving a higher throughput? Is the organization achieving lower operating expenses (Ronan and Pass,

1994:10)? Answering these questions involves comparing measurements of actual performance against a standard of performance.

Generally, three types of standards are applicable for this comparison. A predetermined standard can be established by reviewing an organization's goals and objectives. Historical standards are based upon records of past performance and can be used to compare performance levels. External standards are used to compare similar organizations subject to the same operating factors that affect performance. The best measurements compare actual performance against a predetermined target of performance (Thorn, 1980:33). If actual performance is lower than the target performance, this difference represents the lack of satisfactory performance towards a particular objective. The extent to which the actual measurement matches the target will define the measure of productivity (Sardana and Prem Vrat, 1987:108). Actual VOC rates are compared to a predetermined target of performance (10 percent) intended to represent customer satisfaction. However, no evidence exists to suggest that customers had input in determining the target. As a result, the target could be an invalid representation of customer satisfaction.

A major problem with the selection of variables used in performance measurement systems is that the variables do not measure all aspects of actual inputs and outputs (Mentzer and Konrad, 1991:36). In an effort to overcome this problem, all factors related to the final output of a product or service should be considered when designing a measurement system (Kearney, 1984:42). Because there are many different opinions

pertaining to the characteristics of an effective performance measurement system, establishing such a system is a difficult task. A.T. Kearney established seven criteria essential to an effective performance measurement system:

1. Validity. The most valid measure is one that accurately exemplifies changes in productivity
 2. Coverage. The more completely a measure covers all uses of a resource, the more fully the resource can be tracked.
 3. Comparability. For a productive measure to be traced over time, it must contain a common denominator that allows for the comparison of other organizations at different locations.
 4. Completeness. This emphasizes the extent to which the resources used to produce a service or good are accounted for.
 5. Usefulness. The measure must be of use to the manager in making decisions.
 6. Compatibility. The measure must be compatible with existing data retrieval and reporting methods to be easily implemented in an organization.
 7. Cost Effectiveness. The ultimate cost of the measurement system must be offset by the savings realized through the use of the system.
- (Kearney, 1984:42-43)

Brizius and Campbell, and Hatry and others, characterize an effective measurement system in much the same way:

1. It should be focused on outcomes and quality--not processes.
2. It should help managers improve their organization.
3. It should define outcomes and quality from the customer's perspective.
4. It should use a few select indicators for managers.
5. The information produced should be useful to policy and operational decision makers to help improve their operations.
6. The data should be consistent and valid over time.
7. Comparisons should be provided in relation to standards, baseline data, or targets of desired performance.
8. Reports should be made available to managers and policy makers on a recurring basis that are easy to read and understand. (Kamensky, 1993:401)

According to Vitale, Mavrinac, and Hauser the optimal measurement system should adhere to the following criteria:

1. Accessibility. The measurement system should use data that is already available and easy to retrieve.
 2. Conceptual simplicity. The strategic and operational significance of the measures should be easy to understand. Any measure in which the desired direction of movement is not clear should be avoided.
 3. Relevance. Measures should be actionable and relate to the process or output tracked. If performance does not meet standards, managers should be able to recognize the source of the problem and how best to correct the problem.
 4. Reliability. The measure should track true performance and eliminate "noise."
 5. Dynamism. The measure should be flexible and capable of change.
- (Vitale, Mavrinac, and Hauser, 1994:15)

For the purpose of this research, the essential characteristics of a performance measurement system must include the following:

1. The system must accurately track all resources utilized in the process.
2. The system must aid decision making by identifying problem areas.
3. The system must use data that is compatible with existing information systems.
4. The system must be able to compare performance of organizations located in different locations.
5. The system must track true performance by emphasizing changes in productivity.

Another guideline to follow when establishing an effective performance measurement system is limiting the number of measures to the minimum needed to achieve the desired results and ensure they are related to the objective (Hendricks, 1994:27). If a program has more than 15 measures, they should be reviewed to validate their importance (Meyer, 1994:96). Additionally, the measures should be easily monitored and displayed at all times (Wiley, 1994:362). McMann and Nanni stress these characteristics by stating that measures should be easily understood, simple to accomplish, easy to manage, and cost effective (McMann and Nanni, 1994:56).

VOC is the primary performance measurement indicator of vehicle maintenance units throughout the Air Force. Vehicle maintenance performance is measured in terms of achieving a 10% (or less) VOC rate. If this standard is achieved, the unit is considered an adequate performer. Although this measure uses data that is compatible with existing information systems, this measure does not possess the other essential characteristics listed above. VOC does not track the resources utilized in the maintenance process. VOC tracks the time between the opening and closing of a work order without any regard for resource allocation. This measure of performance also lacks the ability to aid decision makers. Areas of poor performance are not emphasized by this measure. If the vehicle maintenance officer wants to determine the causes of the VOC rate, extensive research must be conducted. Typically, VOC rates are used to compare maintenance units from different bases. This comparison is invalid because VOC rates do not account for differences in independent factors such as manpower, budget levels, and age of the vehicle fleet. Finally, VOC rates do not track true performance. A unit may achieve a lower VOC rating at the expense of performing quality maintenance. As quality maintenance decreases, the time to close work orders also decreases. Although the VOC rate has been reduced, true performance of the unit has decreased.

A study conducted by The Maryland Center for Productivity and Quality of Worklife in 1981 for the Air Force, reported by Howell and Van Sickle in Perceptions Of A Methodology For The Development Of Productivity Indicators, also listed three broad guidelines of an effective performance measurement system. First, performance

measurement systems should include the concepts of productivity, efficiency and effectiveness. Second, measures of efficiency and effectiveness should include such characteristics as completeness, comparability, and acceptability to organization members. Third, measures of productivity should include characteristics such as validity, understandability, and reliability (Howell and Van Sickle, 1982:28-29). Ghobadian and Ashworth emphasize the following guidelines: Performance measurement systems should employ efficiency and effectiveness concepts, be able to identify possible compromises between different areas of performance, and should not be ends in themselves (Ghobadian and Ashworth, 1994:50).

A key factor in these characteristics and guidelines is that performance measures vary from location to location. This variation in performance measures is due to differences in production processes required, age and suitability of equipment, and strengths and weaknesses inherent in the organization. These factors should be taken into account when designing a performance measurement system. Performance reports that are standardized give consistency of reporting and enable comparison between plants. However, the information may be misleading and irrelevant because the reports do not consider variations between plants (Maskell, 1991:26-27).

After relating the aforementioned characteristics and guidelines to the VOC standard, it is apparent that the current performance measurement system lacks several important concepts. The system does not incorporate the concepts of productivity, efficiency, and effectiveness in the VOC measure. As long as the VOC rate decreases, no questions are

asked about how the maintenance tasks were performed. Thus maintenance personnel could waste resources, use improper maintenance procedures, or manipulate work orders to achieve a low VOC rate. Besides not having concepts of productivity, efficiency, and effectiveness, the VOC standard is considered an end in itself. Actual VOC rates have become the standards at certain locations, while the significance of the original target has been lost. Also, the VOC standard does not account for variations in input at different locations. Throughout the Air Force, high VOC rates are associated with poor vehicle maintenance performance and thus it is assumed that the vehicle maintenance unit is not performing satisfactorily. In some cases unsatisfactory performance is the cause, but there are many instances where limited resources, such as money and manpower, drive the high VOC rate. Because there are many different operating environments, Air Force personnel should use performance measurement systems that are able to account for the various inputs that might constrain performance at different locations.

So far, we have discussed and related the VOC standard to the essential characteristics of an effective performance measurement system. The important concepts of any performance measurement system are productivity, effectiveness, and efficiency. In the following sections the relationships between these concepts and the VOC standard are discussed.

Productivity Concept

More than 15 different definitions of productivity have been identified, leading to confusion and misunderstanding about its meaning. However, several definitions are

presented in this section that meet the needs of this research. Mali defines productivity as "the measure of how well resources are brought together in organizations and utilized for accomplishing a set of results. Productivity is reaching the highest level of performance with the least expenditure of resources" (Mali, 1978:4-6). In other words, productivity is a combination of effectiveness and efficiency (Shenhav, Shrum, and Alon, 1994:754). A study of the federal government conducted by the Civil Service Commission, the General Accounting Office, and the Office of Management and Budget and Audit stressed the importance of this definition and its applicability to government organizations (Mali, 1978:83).

Sardana and Prem Vrat developed a more formal definition of productivity. They contend that "productivity as an index of system (subsystem) performance indicates the extent of actual accomplishment of performance objective(s) in relation to the attainable level in a given external environment." They propose that productivity be looked at in broad perspectives "as a parameter of the performance of a system to meet specific objectives of measurement" and, therefore, be interrelated with the meaning of measurement (Sardana and Prem Vrat, 1987:105). Productivity is the relationship between output (goods or services provided) and input (resources used in producing the output) (Aboganda, 1994:94).

Productivity is also defined as a "systematic concept concerning the conversion of inputs to outputs by the system under consideration" (Adam, Hershauer, and Ruch, 1981:10). Figure 3 graphically portrays Adam's definition of productivity: This expanded definition is referred to as "total productivity." If outputs are not related to all inputs

$\text{Productivity} = \frac{\text{Outputs}}{\text{Labor} + \text{Capital} + \text{Materials} + \text{Energy}}$

Figure 3. Productivity Defined (Adam, Hershauer, and Ruch, 1981:10)

affecting output, an incomplete measurement results. This type of measure, called partial factor productivity, does not account for total firm productivity and should be avoided in assessing the performance of the firm (Lee, 1991:11). For example, efficient labor can produce a large quantity of inventory, but if the labor accomplishes this task by consuming more input than needed, the end result is counterproductive. Although the labor is efficient, the end result is flawed. VOC rates do not include all the inputs required to perform the maintenance function. These rates can be reduced by spending additional money for contracting, performing maintenance that does not meet safety requirements, or replacing parts instead of rebuilding them.

Most definitions of productivity contain a ratio measuring outputs against inputs. Mali not only relates productivity as a ratio, but uses a productivity index to explain the relationship between efficiency and effectiveness. He states that productivity is a combination of effectiveness and efficiency. This relationship is shown in Figure 4.

$\text{Productivity index} = \frac{\text{output obtained}}{\text{input expended}} = \frac{\text{performance achieved}}{\text{resources consumed}} = \frac{\text{effectiveness}}{\text{efficiency}}$

Figure 4. Productivity Index (Mali, 1978:7)

This measurement of output to input is essential in any organization.

Productivity, as defined for the purpose of this paper, is both a measure of effectiveness and efficiency. This relationship is shown in Figure 5. Current productivity measurement of vehicle maintenance units is expressed solely in terms of effectiveness and does not account for various input factors to give a true measure of productivity. However, there is no concern about the amount of resources expended in achieving the performance. The VOC standard considers achieving the organizational goal (effectiveness), but does not consider the inputs utilized (efficiency), and thus no measure of true productivity is possible.

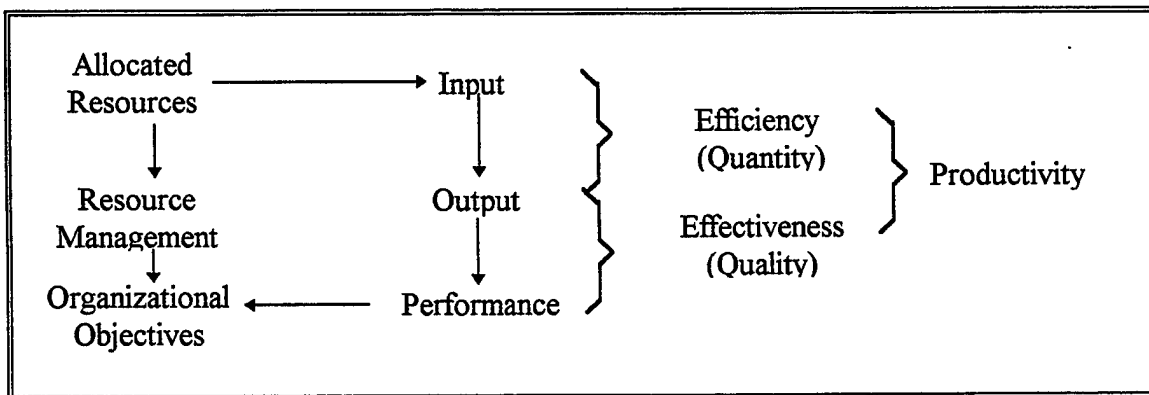


Figure 5. Components of Productivity (Thorn, 1980:31)

Effectiveness Concept

Effectiveness has many definitions applicable to different operating environments. To identify which definition or combinations of definitions is applicable to vehicle maintenance units, a review of the most popular definitions is necessary. The *legitimacy model* measures effectiveness based on organizational survival. Legitimate activities, as

viewed by the external public, are pursued by the organization to ensure longevity. This model is most useful on the macro level when assessing which organizations are likely to survive (Cameron, 1984:278). Satisfying the constituencies of an organization is the measure of effectiveness for the *strategic constituencies model*. This model should be used to assess effectiveness when the constituencies of an organization have powerful influence over the course of action the organization pursues (Cameron, 1984:277). The *system resource model* emphasizes the acquisition of needed resources to accomplish organizational goals. This model should be used to assess effectiveness when there is a clear relationship between the resources received and the tasks of the organization. Any organization that acquires resources and stores them without any intention of using the resources is increasing organizational waste and should not be judged to be effective (Cameron, 1984:277). The last model of effectiveness is the *goal model*. This model measures effectiveness by determining the extent an organization achieves its stated goals and objectives. This model should be used when an organization has clearly defined, time based, measurable goals (Cameron, 1984:276). Because VOC rates are time related, clearly defined, and measurable, the goal model of effectiveness will be used for this research. The goal of the VOC rate is to satisfy the customer by ensuring there is an adequate number of vehicles available at all times.

From the perspective of the customer, effectiveness is “doing the right things seen through the customer’s eyes” (Theeuwes and Adriaansen, 1994:91). Satisfying the customer involves transforming inputs, through a number of value added processes, to

outputs. The value added processes must be considered important to the customer for the organization to be effective (Dumond, 1994A:4). From an organizational perspective, this concept is viewed as a function of achieving company goals and objectives (Dumond, 1994:17). Stated simply, effectiveness is how well a responsibility center's outputs satisfy the goals of the organization (Keating and Keating, 1981:43).

The National Consumer Council of London, England conducted a study which emphasized effectiveness within local government. Because local governments provide services, the effectiveness of government agencies should be measured in terms of the "nature, quantity and quality of service, their effect and extent to which they meet consumer and community needs (Ghobadian and Ashworth, 1994:43)." This study identified four questions that effectiveness measures need to address. First, effectiveness measures need to answer how well the product or service satisfies the customer's need. Second, effectiveness measures need to determine if the product or service is easy to use. The third question should address the side effects of the service or product. Finally, the measure should determine if the product or service is worthwhile from an economy perspective (Is the taxpayer's money being used efficiently?) (Ghobadian and Ashworth, 1994:43).

Based on the aforementioned information, measures of vehicle maintenance effectiveness should provide an indicator of the maintenance program's value, indicate the extent to which the right things are being accomplished, and provide information to track performance and implement improvements (Walker and Cooper, 1990:28).

An important theme present in the definitions of effectiveness and the questions about effectiveness is the satisfaction of the customer. For the purpose of this research, effectiveness is defined as achieving both customer satisfaction and organizational goals. Although it was previously stated that VOC rates account for effectiveness, in reality there is no measure of effectiveness. There is no clear-cut relationship established between a 10 percent VOC rate and customer satisfaction. Vehicle maintenance units may attain the organizational goal of 10 percent but still not achieve true customer satisfaction.

Efficiency Concept

Efficiency is a narrow and well-defined concept when compared to either productivity or effectiveness. Efficiency refers to whether an output is produced at least cost, or a given amount of resources is used in such a way to produce the greatest results (Rushing, 1974:477). "The degree of conversion of a resource from its initial form to its final form with the help of technology, methods, and manpower available in a given period" is another definition of efficiency. This definition refers to the level of resources consumed in achieving results (Ray and Sahu, 1990:154). Dumond states that the efficiency of an organization can be measured by the ratio of the amount of resources used in producing an output (Dumond, 1994:17).

According to the aforementioned definitions, efficiency involves a comparison or ratio of inputs utilized to outputs produced with no regard to whether the output supports organizational goals. Therefore, units that utilize less resources when accomplishing their

tasks are more efficient. However, if the outputs do not contribute to the attainment of organizational goals, these units are not effective (Thorn, 1980:30; Mentzer and Konrad, 1991:34). The following example illustrates how a unit can be efficient and not contribute to organizational goals. Top management's goal for an injection molding unit was to increase efficiency and lower costs. The department achieved both these goals by producing more molds than necessary. The production of extra molds led to high labor and machine utilization rates and low overhead costs because costs were allocated to more parts. Although management praised this unit, the unit actually added additional costs to the organization in the forms of extra inventory, increased energy bills, and increased wear and tear of the machinery. Overall, this unit was efficient, but lacked effectiveness (Nemeth, 1991:84).

For the purpose of this research, efficiency is defined as the ratio of inputs consumed to outputs produced. As stated previously, VOC rates do not account for efficiency because the resources consumed when repairing a vehicle are not measured.

Summary of Ideas Presented

In this section we developed five essential characteristics of a performance measurement system and related the current VOC standard to these characteristics. This comparison demonstrated that the VOC standard did not possess the essential characteristics of an effective performance measurement system. Additionally, the relationship between VOC rates and the concepts of productivity, effectiveness, and

efficiency were discussed. The overall productivity of an organization is measured by outputs achieved (effectiveness) in meeting an objective with minimum use of inputs (efficiency). While efficiency is focused on how well an organization uses resources available to produce output, effectiveness is objective-oriented. Efficiency and effectiveness are inter-related to productivity; both are focused on outputs.

Current VOC rates strive to measure effectiveness, but there is no customer input as to what constitutes customer satisfaction. Thus, vehicle maintenance units do not know if their operations are effective. There is no measure of inputs consumed when producing output, which leads to the conclusion that vehicle maintenance units do not know if their operations are efficient. If there is no measure of effectiveness and efficiency, true productivity is impossible to determine. Based on the characteristics of a performance measurement system, the concepts of productivity, effectiveness, and efficiency, we conclude that the current VOC standard is not useful. In an attempt to establish a performance measurement system that would be useful to vehicle maintenance units, the following section on performance measurement in the government is presented.

Performance Measurement In The Government

The overall goal of this section is to review research about performance measurement within the government and suggest a possible performance measurement system for vehicle maintenance units. To accomplish this task, a review of performance measurement within the DOD and government agencies will be presented.

Although decision-makers often advocate and praise the use of performance measurement within government, most agencies make little use of performance measurement systems. A 1971 study conducted by the Urban Institute concluded that of thirty local governments, only 23 percent of the performance measures included the concepts of efficiency and only 13 percent included the concepts of effectiveness (Ammons, 1995:41-42). Follow-on research conducted in 1976 by the Urban Institute found that of 247 local governments, only 10 percent performance measures included the concepts of efficiency and only 25 percent included concepts of effectiveness (Hatry, 1978:29). At the state level (32 states), 47 percent of the respondents rated existing efficiency measures as barely adequate and 91 percent rated effectiveness measures as barely adequate (Hatry, 1978:29). In 1987, LeGrotte examined sixty cities with populations over 100,000 that had responsibility for police, fire, and library functions. The results showed that 40 percent of these agencies had no performance measurement system. Of those that had a system, only 45 percent included the concept of effectiveness and only 16 percent included the concept of efficiency (Ammons, 1995:42).

Realizing the importance of performance measurement and the lack of its use within government organizations, the DOD established two directives that emphasized performance measurement. In DOD Directives 5010.31 and 5010.34, DOD Productivity Program, the government set out to improve the productivity of defense organizations. DOD Directive 5010.31 mandates management to focus on improving productivity by using available resources and improving methods of operations. DOD Directive 5010.34

mandates that defense organizations operate efficiently and effectively. The DOD realizes there is a need to improve the efficiency and effectiveness of its operations to improve productivity. In a separate directive from the Office of Management and Budget, dated 9 July 1973, the concept of productivity is further emphasized. The directive mandates the establishment of a system for measuring and evaluating productivity in government organizations (Howell and Van Sickle, 1982:6-7).

Research conducted by Weisert and Clarke in 1972, entitled Determination of Performance Indicators For The United States Air Force Base Level Transportation Function, found that less than 30 percent of the respondents were able to reach agreement on a desirable level of performance. Most of these disagreements were with performance indicators presently in use that were based on generic Air Force standards such as the VOC standard. In addition, the researchers concluded that the information system available to transportation managers (VIMS) did not provide the information needed or desired. It was, therefore, of little use to them in making decisions (Weisert and Clarke, 1972:82-83).

Research conducted in 1979 by Baumgartel and Johnson, entitled Productivity Measurement In A Base Level USAF Civil Engineering Organization, concludes that the "productivity for a branch is equal to the sum of that branch's performance indicators for all of its objectives and goals, divided by the total number of performance indicators, divided by the total input to the branch" (Baumgartel and Johnson, 1979:29). They conclude that this model could effectively measure the productivity at the branch level

because it is based on evaluation of actual results, desired results and inputs. Because few output measurement requirements are used above base level, they recommend the desired output level (standard) should be established at base level to evaluate performance (Baumgartel and Johnson, 1979:107-108).

A 1982 study by Howell and Van Sickle, entitled Perceptions of a Methodology for the Development of Productivity Indicators, reaches several conclusions about developing productivity indicators using criteria established by The Maryland Center for Productivity and Quality of Worklife study in 1981. The first conclusion was that the indicators were more acceptable and meaningful than previous indicators because they incorporated the concepts of effectiveness and efficiency. Effectiveness and efficiency measurements included the characteristics of completeness, comparability, input coverage, compatibility with existing input sources, cost effectiveness, consistency across organizations, and acceptability to organization members. The study also determined that these indicators might give management a better "picture" of an organization's productivity and provide a better understanding of productivity and effectiveness (Howell and Van Sickle, 1982:77).

Research conducted by Brewer in 1989, entitled Perceptions Of Air Force Base-Level Transportation Officers Towards The Effectiveness Of Air Force Base-Level Transportation Performance Measurement Indicators, reaches many of the same conclusion as the 1972 study by Weisert and Clarke. The research concluded that a majority of transportation officers (56.4%) viewed many of the current transportation performance indicators as meeting the seven characteristics of effective performance

measurement indicators established by A. T. Kearney. These characteristics are validity, coverage, comparability, completeness, usefulness, compatibility and cost effectiveness. The study concluded that because there was significant disagreement (43.6%) with the performance indicators, further research should be conducted to eliminate or modify indicators that do not meet these characteristics. In addition, a majority of transportation officers perceive the necessity of including manpower, environment, and budget in performance measurement design and they were not in favor of using current performance indicators to cross-compare organizations. The VIMS system was viewed as outdated because it does not reflect "current performance measurement philosophy." Performance standards need to be designed and interpreted by accounting for unique operational situations. Included in this sensitivity are base location, climate, training levels of personnel, and age of the vehicle fleet. Performance measurement should include "required manpower" as a constraint. Finally, the research concluded that if present performance indicators are not modified to include independent variables such as manpower, base location, and budget, they should not be used to cross-compare organizations (Brewer, 1989:92-96).

The reviewed research highlights the need for a new performance measurement system within vehicle maintenance and emphasizes the following points:

1. Performance indicators within government should include the concepts of efficiency and effectiveness.
2. The information available from VIMS does not aid the decision-making process.
3. Desired performance standards should be determined at base level.
4. Performance measurement needs to account for factors such as manpower and budget.

5. VOC rates should not be used to cross-compare units at different locations unless independent variables such as manpower, age of fleet, base location, and operating environment are accounted for in the performance measure.

Performance Measurement Systems For Vehicle Maintenance

In an effort to satisfy the aforementioned issues about vehicle maintenance performance measurement, a review was conducted to discover the type of performance measurement system that could be useful for vehicle maintenance. The performance measurement systems of Air Force aircraft maintenance units and the U.S. Postal Service were examined.

A study conducted in 1991 by Jung, entitled Determining Production Capability In Aircraft Maintenance: A Regression Analysis, concludes that, based on the need for identification and consideration of independent variables affecting maintenance constraints and production outputs, linear regression is the appropriate technique in evaluating performance (Jung, 1991:25). The findings of his research are listed below:

1. The use of productivity measures in evaluating aircraft maintenance organizations should provide insight and be "tempered" with the fact that aircraft maintenance is a dynamic environment.
2. Maintenance managers using the same performance measures for different situations and environments to assess performance may find "evaluations divergent from reality."
3. Maintenance managers should not evaluate all aircraft using the same production measurement indicators.
4. Using a set of indicators for one aircraft may show high performance levels, while using the same measures for another aircraft may indicate low performance levels. (Jung, 1991:115)

Follow-on research conducted by Gray and Ranalli in 1993, entitled An Evaluation Of Aircraft Maintenance Performance Factors In The Objective Wing, concludes that the method used most often for creating performance measurement models is regression analysis. They verified the conclusion made by Jung that each aircraft maintenance unit was affected by different independent variables and concluded that no single model was appropriate for every unit. They also concluded that regression models were useful for predicting aircraft maintenance performance measures.

The methodology used by Bradley and Baron in measuring the performance of the U.S. Postal Service involves multiple regression analysis. They refer to their model as "operating efficiency" and state this method is useful for any organization desiring a single measure of performance and wanting to determine why performance varies from place to place or over a period of time (Appendix A) (Bradley and Baron, 1993:450-454).

The variables include factors such as the age of the facility, amount of automated equipment, and facility size. Statistical analysis determined which variables were relevant factors influencing operating efficiency and quantified the effect of each variable on the efficiency level of the operation. The researchers stressed the importance of dividing the variables into those that can be controlled by management and those that can not. This division of variables is important when comparing performance at different locations. For example, operating efficiency at an automated plant would be higher than that of an older, low technology facility. Because all relevant variables are considered using this approach, the operating efficiency of one operation can be compared against a "model" plant having

the same characteristics. This model also allows for the interaction of variables on one another. An illustration given was that operating efficiency increases with use of automation, but decreases with the age of the equipment (Bradley and Baron, 1993:452-454). For example, the U.S. Postal Service used the analysis procedure to determine the effect on operating efficiency if the values of contributing factors were changed. Figure 7 shows the change in operating efficiency due to a 10 percent increase in the factor listed.

Factor	Description	Effect On Operating Efficiency
Degree of Automation	Percentage of piece handlings performed on automated equipment	9.55
Volume of Mail	Total piece handlings	2.51
Age of Facility	Age measured in years	-0.31
Degree of Support Costs	Percentage of labor hours in human resource and training functions	1.03
Space Utilization	Number of piece handlings per square foot of mail processing space	0.65
Degree of Flex Labor	Percentage of workforce that is classified as part-time or casual	0.37
Delivery Network	Number of delivery points for a given volume	-2.25
Number of Locations	Number of locations in which mail processing takes place	-1.13

Figure 6. Factors Affecting Operating Efficiency (Bradley and Baron, 1993:455)

A major benefit of this type of performance measurement is that it can be used to determine why operating efficiencies vary from unit to unit or over periods of time. It can also be used to determine which variables contribute the most to productivity. This approach has aided managers in making difficult decisions such as where to locate new

facilities, types of capital investments to make, and decisions concerning performance measurements themselves (Bradley and Baron, 1993:456).

Ray and Sahu advocate the use of regression models as a performance indicator for productivity, efficiency, and effectiveness. They conclude that regression models are suitable for service organizations that want to measure the effect of both quantifiable and intangible factors that affect performance (Ray and Sahu, 1990:162).

Chapter Summary

This literature review examined relevant information about performance measurement systems and how effective systems were related to productivity, effectiveness, and efficiency. Prior studies were also examined to determine the applicability of multiple regression models in measuring performance within the government. These studies revealed dissatisfaction with current measurement systems utilized in Air Force vehicle maintenance units.

Specifically, this review identified that performance measurement systems within the government lacked the concepts of efficiency and effectiveness. Research focused on vehicle maintenance units also indicated this same problem. Additionally, the research highlighted the inadequacies of the VOC standard and stressed the importance of developing a new performance standard that allows for the cross-comparison of units.

Research that focused on USAF aircraft maintenance units and the U.S. Postal Service indicated the usefulness of using multiple regression analysis as a form of performance

measurement. The benefits of multiple regression measurement systems were that they aided in the decision-making process, allowed comparison of organizations, could be used to determine causes of inefficiencies within an organization, and allowed for a single measure of performance.

III. Methodology

Introduction

Given a premise that current vehicle out-of-commission standards are not indicative of how a vehicle maintenance unit is performing and can not be used to effectively cross-compare units, this chapter describes the methodology used to answer the research question presented in Chapter I. This question asked what the best measure of efficiency, effectiveness and productivity for Air Force vehicle maintenance units was that will allow accurate cross-comparison of these units. To further define and focus on this question, eight investigative questions were developed. These are listed below.

1. How are efficiency, effectiveness and productivity related to performance measurement?
2. Why are more relevant performance measurement indicators needed in government organizations?
3. How do vehicle maintenance officers perceive the VOC standard?
4. Should independent factors be included when establishing a performance standard?
5. Is multiple regression analysis suitable for evaluating the performance of vehicle maintenance units?
6. What independent variables impact the performance of vehicle maintenance units the most?
7. Are there differences in perceptions, based on rank, vehicle maintenance experience, and current duty position, about an acceptable vehicle maintenance performance standard?
8. Are there differences in perceptions, based on rank, vehicle maintenance experience, and current position, about the most important independent variables impacting vehicle maintenance performance?

This chapter describes the population and sample, survey instruments, sampling plan, validation of the survey, data collection plan, survey analysis, the steps in formulating a

regression model, the statistical design, and the assumptions and limitations used to answer investigative questions three, four, six, seven, and eight. Further, a description of a regression model will be presented along with the methodology used to establish the model that should be used by vehicle maintenance units.

Population And Sample

The population for this study is Air Force transportation officers. The sample tested consisted of transportation officers with vehicle maintenance experience. These experts answered investigative question number three. According to AFMPC, there were 168 transportation officers with Special Experience Identifier (SEI), LK3. This SEI is used to identify logistics officers with vehicle management experience. Air Force Manual 36-2105 describes officers assigned this SEI as having "12 months' experience serving as a vehicle maintenance, vehicle management, or vehicle operations officer, including civil engineering heavy equipment (RED HORSE) vehicle maintenance shops" (Department of the Air Force, 1994A:296). Surveys returned from respondents with no vehicle maintenance experience were considered for inclusion to provide additional discriminators for testing purposes.

Survey Instruments

A self-administered questionnaire was chosen to answer investigative question number three. Because of the large sample size and geographic diversification of officers

surveyed, this type of instrument was more efficient and less costly to administer. Also, the time required to administer a mail survey was minimal when compared to other survey instruments.

Sampling Plan

A pilot survey (Appendix B) was developed and administered to transportation officers at the Air Force Institute of Technology to help identify possible independent variables affecting vehicle maintenance performance. Cronbach's coefficient alpha testing was performed using SAS to determine the internal consistency of the performance scale. An alpha coefficient of .84 was obtained, indicating a high degree of internal consistency (Shane, 1995) (Appendix C). Next, the questionnaire was sent to the USAF Survey Control Office, Military Personnel Center, Randolph AFB, Texas. The center approved the survey with minor corrections based on the Air University Sampling and Surveying Handbook and assigned a survey control number (Appendix D). Once the changes were made, the final survey was distributed to the population sample (Appendix E). The primary objective of this survey was to solicit responses from transportation officers about a suitable performance measurement standard for vehicle maintenance units and their perceptions about variables most affecting performance levels. The questionnaire was divided into three major sections. Section I, questions one through thirteen, consisted of background information and demographic data and provided a smooth transition to the more thought-provoking questions in the following sections. Section II, questions 14

through 27, were designed to gather information about a vehicle maintenance performance measurement standard and the independent variables affecting vehicle maintenance performance. Question 14 asked respondents whether independent factors should be included when establishing a performance standard, with responses based on the following Likert Scale:

- 1 - Strongly Disagree
- 2 - Slightly Disagree
- 3 - Disagree
- 4 - Neutral
- 5 - Slightly Agree
- 6 - Agree
- 7 - Strongly Agree

Questions 15 through 27 included the independent variables identified in the pilot survey and asked the respondents to rate the impact of these variables on vehicle maintenance performance using the following Likert scale:

- 1 - Not At All
- 2 - Slight Extent
- 3 - Moderate Extent
- 4 - Great Extent
- 5 - Very Great Extent

Section III, question 28, consisted of an open-ended question asking respondents to describe independent variables, not already listed in Section II, that affect their performance level.

Validation

Validity of this questionnaire was accomplished by using an expert in the area of research methods and an expert in transportation to determine if the survey was effective in answering question number three. This test yielded only minor problems and changes that were incorporated into the final survey. This procedure is an accepted means of validating survey instruments (Emory, 1995:149).

Data Collection Plan

Data collected from the surveys consisted of opinions. Opinions are considered to be valid if questions asked are clearly stated and understood by the respondents. This validation was established by the experts prior to the administration of the survey to the population sample.

Pre-printed address labels obtained from the Air Force world wide locator were attached to the full size envelopes to ensure timely distribution of the questionnaires. Accompanying the questionnaires were a computer scan sheet, cover letter, and a self-addressed, stamped return envelope which enabled prompt return of the surveys. The questionnaires were mailed from the local United States Post Office on 19 May, 1995 and the last survey was returned on 31 July, 1995.

Survey Analysis

Section I of the surveys was analyzed to determine the demographic data of the respondents. Of special interest were the rank, vehicle maintenance experience, and

current position subgroups so that differences in perceptions could be identified. These subgroups were selected because they provided several different view points on the perceptions of how one might perceive vehicle maintenance performance. For example, an individual with maintenance experience knows what types of factors impact performance the most when compared to someone with no experience. Additionally, an individual currently in a VMO position might possess different perceptions from someone who was a VMO in the past.

Question 14 was analyzed to determine both the adequacy of the current VOC standard and the importance of including independent factors when establishing a performance standard. Additionally, questions 15 through 27 were analyzed to determine the relative importance of the independent factors gathered from the pilot survey. The mean value of each variable was determined using STATISTIX and listed in rank order. These variables were tested, from highest mean response rate to lowest mean response rate, until a statistically different mean response rate was discovered. This statistically different response rate represented the cut-off point, and all factors falling below were excluded from further analysis. A second criteria for selecting factors that impact vehicle maintenance performance the most was that the mean response rate must be greater than four. This criteria ensured that only the factors perceived as impacting vehicle maintenance performance to a "Great Extent" or "Very Great Extent" were included for further analysis. Section III was analyzed to determine if other independent variables not listed in Section II were considered important by the sample population. If the same

independent variables were listed by a large proportion of respondents and were not contained in Section II, they were considered for additional research. Once the most relevant independent variables were established, collection of data pertaining to these variables would be possible.

Formulating A Regression Model

The first step in formulating a suitable model was to "hypothesize the deterministic component of the model that relates the mean, $E(\gamma)$, to the independent variable x (McClave, 1994:461)." This was considered at the time to be vehicle out-of-commission rates. The model would be shown as:

$$\gamma = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\chi_3 + \beta_4\chi_4 + \dots + \beta_i\chi_i \quad (1)$$

where: γ = vehicle out-of-commission rate = the response variable we wish to predict; β_i are the unknown independent variable parameters and χ_i are information contributing variables.

The second step was to estimate the unknown parameters in the model using the sample data. Because the number of independent variables was expected to be large, and formulation of a regression model would be difficult under these conditions, stepwise regression procedures would be used to interpret the possible interaction between variables and possible higher order terms. Stepwise regression would result in a "model containing only those terms with τ values that are significant at the specified α level. Thus, in most practical situations, only several of the large number of independent variables will remain" (McClave, 1994:674-675).

The next step would be to analyze the four assumptions of the probability distribution associated with the random error component, ϵ . The first assumption needing to be satisfied was that the mean of the probability distribution would equal zero. Next, the variance of the probability distribution of ϵ must equal σ^2 and be normal. Finally, the values of ϵ associated with any two values of γ need to be independent (McClave, 1994:472).

The fourth step would include testing the usefulness of the model. Because stepwise regression analyzes the individual β parameters and includes only parameters that contribute significantly to the model, evaluation of R^2 , the coefficient of determination, would determine the usefulness of the model in this step. R^2 "represents the proportion of the total sample variability around \bar{y} that is explained by the linear relationship between y and x ." An R^2 value of 1 indicates all variability around \bar{y} is explained by the relationship between x and y (McClave, 1994:489).

Statistical Design

Although the survey questionnaire used an ordinal scale usually associated with the calculations of percentages, means, and modes, there was evidence supporting the use of an ordinal scale in the same way as a ratio or interval scale:

In general, we are perfectly safe in calculating any statistic we want on any set of measurements that have the properties of an ordinal scale. There is definitive evidence that statistics calculated on an ordinal measurements are just as reliable and meaningful as statistics calculated on an interval or ratio scales of measurements. (Baker and others, 1966:309)

Taking the conservative approach, and avoiding the assumptions of an ordinal scale, this research used nonparametric tests to determine if there were any statistically different mean responses between subgroups. Additionally, the non-normality of the responses indicated that nonparametric procedures should be used. A Wilks-Shapiro statistic of .9 or greater indicates normality of the data. However, not a single response achieved .9 or higher. The nonparametric test used in this research to compare subgroups was the Wilcoxon Rank Sum Test. This test is almost as powerful as the parametric two-sample t -test and is more powerful than the nonparametric median test (Statistix, 1992:116). Because our subgroup populations were larger than 10, the use of the Z-statistic was permissible in the Wilcoxon Rank Sum Test (McClave and Benson, 1994:930). The following procedure was employed to test each subgroup. The null hypothesis (H_0) stated that the two populations had identical response rates. The alternate hypothesis (H_a) stated that the two populations had different response rates. The test statistic was calculated by STATISTIX. The rejection region for a two-tailed test and an α equal to .10 was $|z| > 1.645$. Any test statistic meeting this criteria results in a rejection of the H_0 and a conclusion that the populations have different response rates at α .10 level of significance. The survey results indicated that the level of significance was .0676. Taking the conservative approach, the research team decided to use a significance level of 0.10.

Assumptions And Limitations

This research effort assumed that data collected from respondents was accurate and reflected actual transportation officers' perceptions and view points about independent factors affecting vehicle maintenance performance levels.

Summary

This chapter described the research population and sample, survey instruments, sampling plan, validation of the survey, data collection plan, survey analysis, and the statistical design. Also presented was a description of a regression model, the methodology used to establish a useful model, and the steps necessary for the development of a regression model. Assumptions pertaining to the data collection procedure were also stated. This methodology was used to answer investigative questions three, four, six, seven, and eight. Chapter IV presents results of our analysis based on this research methodology and provides information to answer the aforementioned investigative questions.

IV. Results And Analysis

Introduction

This chapter analyzes the data from the survey questionnaires and presents the results of the analysis. This chapter is divided into the following sections: (1) survey response rate, (2) results of the reliability analysis, (3) sample demographics, (4) importance placed on the current VOC standard, (5) percentage response results, (6) independent factor selection, (7) mean response results by subgroup, (8) Wilcoxon Rank Sum Tests for selected subgroups and performance factors, (9) explanation of significantly different perceptions, and (10) examination of the comments from the survey respondents.

Generalized test results are presented in this chapter for all statistical analysis and detailed results are found in Appendix H.

Survey Response Rate

Surveys were sent to 168 transportation officers identified by the Military Personnel Center (MPC) as having vehicle maintenance experience and possessing Special Experience Identifier (SEI) LK3. Although MPC identified 168 individuals as possessing SEI LK3, 15 returned questionnaires indicated that respondents had no vehicle maintenance experience (13.4%). It was decided to use these responses as a means of comparison for the other data. 112 surveys were returned by respondents which resulted in an effective return rate of 67 percent. Additionally, seven surveys were returned because they were undeliverable. The confidence level for the results of the analysis was

calculated to be 93.24 percent based on the aforementioned sample size using the following formula.

$$n = \frac{NZ^2 \times .25}{(d^2 \times (N-1)) + (Z^2 \times .25)} \quad (2)$$

where: n = sample size (112)

N = total population size (168)

d = precision or confidence level desired (5%- .05)

Z = different factor for each confidence level (unknown)

Reliability Analysis Results

Although the pilot survey had a Cronbach alpha coefficient of .84, indicating a high degree of internal consistency and reliability, the research team decided to test for reliability using the data from the final survey. The internal consistency and reliability of the final survey data achieved an alpha coefficient of .84, thus validating the results of the pilot study.

Sample Demographics

The entire listing of the demographic data appears in Appendix I. This section reports on specific demographic information useful as discriminators for this research.

Specifically, 5.4 percent of the respondents were second or first lieutenants, 33.9 percent were captains, 42.9 percent were majors, and 10.7 percent were lieutenant colonels. The final 7.1 percent of respondents were in the "Other" category consisting of enlisted and

civilian vehicle maintenance managers. All surveys were addressed to officers identified by MPC, but it appears that maintenance managers holding their positions at the time the surveys were distributed responded in their place. Of these respondents, 92 percent possessed a transportation primary AFSC and 88.4 percent possessed a transportation duty AFSC. The majority of respondents were from the Air Mobility Command (AMC) with 31.3 percent, followed by the Air Combat Command (ACC) with 13.4 percent. Additionally, a large proportion of respondents, 33 percent, came from locations that were not offered as choices on the survey. Among others, these consisted of the Office of the Secretary of Defense (OSD), the Military Traffic Management Command (MTMC), the Air Education and Training Command (AETC), the US Special Operations Command (SOC), and the US Transportation Command (TRANSCOM).

As part of the methodology, the sampling plan focused on transportation officers with vehicle maintenance experience to receive valid responses. For the most part, the sampling plan was successful. Nearly 86.6 percent of the officers had at least one or more years experience as a vehicle maintenance officer, and only 13.4 percent had no experience at all. The analysis of this latter group will be accomplished in a later section.

Importance Of The Current VOC Standard

As stated in Chapter II, the VOC rate was the primary performance indicator for vehicle maintenance units. Data from the survey respondents indicated the importance of this performance measure. Of the transportation officers currently serving in positions

with vehicle maintenance responsibilities, 88.5 percent were required to meet or exceed the standard 10 percent VOC rate. However, 34.6 percent of respondents were required to maintain a VOC rate of less than 10 percent. They had adopted more stringent standards to operate under and, although limited in number, were found in AMC, ACC, and AFMC. The VOC standard for these respondents fell in a range from four to eight percent.

The VOC standard was not a performance indicator that went unnoticed. According to the respondents, 55.5 percent were required to brief squadron commanders, group commanders, wing commanders and MAJCOM personnel on a regular basis. In addition, 77 percent were required to brief their MAJCOM, 67 percent were required to brief at the Wing level, and 78 percent were required to brief VOC results at the unit level on a regular basis.

Percentage Response Results

Section II of the survey represented the primary area of interest in this research effort. The two goals of this section were to determine if independent factors should be considered when establishing an effective performance measurement standard and what factors impact the performance levels of vehicle maintenance units the most. Question 14, the first question in this section, asked: "When manpower levels are established, various factors are used to determine what these levels should be. To what extent do you agree or disagree that these type of factors, such as available manpower, age of vehicle fleet,

budget levels, etc., should be considered when establishing a vehicle maintenance performance standard?" Their responses were based on the following Likert scale:

Strongly Disagree	Slightly Disagree	Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1-----	2-----	3-----	4-----	5-----	6-----	7-----

Although vehicle maintenance units are subject to VOC standards, a large majority of respondents, 88.4 percent, stated that the standard should account for independent factors impacting their performance level. Figure 7 graphically portrays the overwhelming number of respondents that believe independent factors should be considered when establishing a vehicle maintenance performance standard. The complete breakdown of

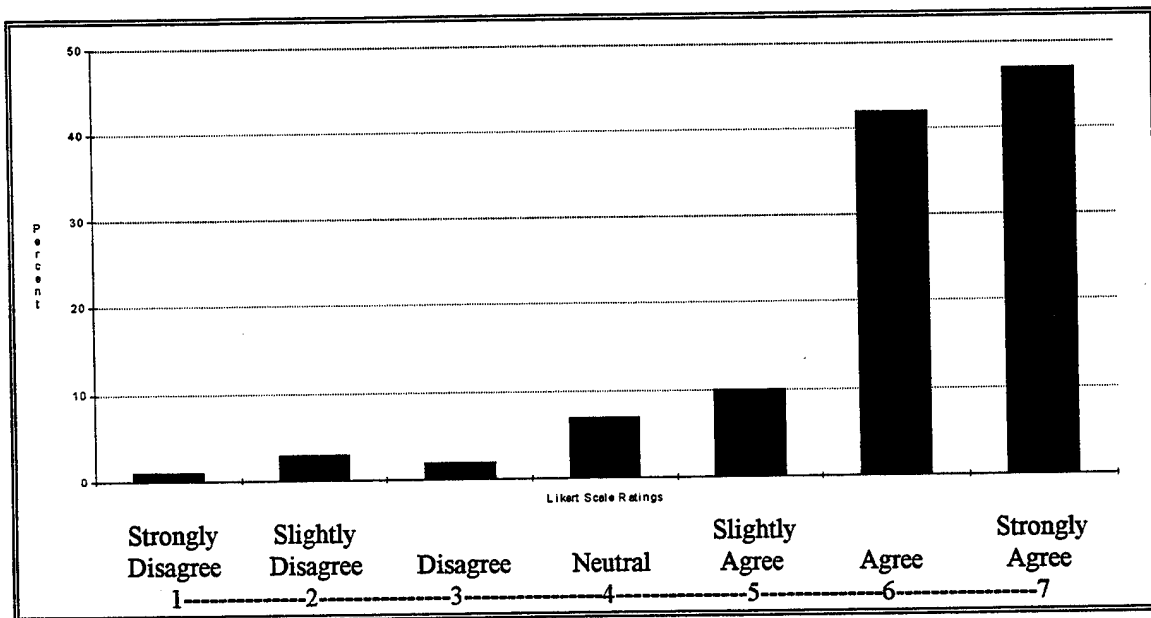


Figure 7. Question 14 Response Breakdown

responses is shown in Table 1. From these responses, a performance standard that includes such factors as available manpower, age of vehicle fleet, and budget levels should be used to measure vehicle maintenance performance.

Table 2. Response Results for Question 14.

Response Statement	Responses	Response (%)	Cumulative (%)
(7) Strongly Agree	47	42.0	42.0
(6) Agree	42	37.5	79.5
(5) Slightly Agree	10	8.9	88.4
(4) Neutral	7	6.3	94.7
(3) Slightly Disagree	2	1.8	96.5
(2) Disagree	3	2.7	99.2
(1) Strongly Disagree	1	0.9	100.0

Questions 15-27 were designed to determine how respondents viewed the impact of various independent factors on the performance of vehicle maintenance units. All respondents were asked to reply to the following statement: "To what extent do you believe each of the following independent factors impact the performance level of a vehicle maintenance unit?" All questions were answered using the following Likert scale:

Not At All	Slight Extent	Moderate Extent	Great Extent	Very Great Extent
1-----	2-----	3-----	4-----	5-----

Responses to these questions are shown in Table 3. The factors receiving the most ratings

Table 3. Vehicle Maintenance Performance Measurement Factors

Independent Factors	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)
15. Available manpower	0.0	0.0	4.5	48.2	47.3
16. Training level of assigned personnel	0.0	0.0	4.5	42.0	53.6
17. Experience (# of years) of assigned personnel	0.9	1.8	18.8	46.4	32.1
18. Budget available for vehicle maintenance	0.0	0.9	12.5	35.7	50.9
19. Age of vehicle fleet	0.9	0.9	25.0	33.0	40.2
20. Parts availability	0.0	0.0	11.6	33.9	54.5
21. Severity of climate	1.8	12.5	48.2	30.4	7.1
22. Availability of warranty service	6.3	25.0	45.5	19.6	3.6
23. Age of maintenance facility	4.5	24.1	45.5	22.3	3.6
24. Size of maintenance facility	1.8	14.3	40.2	33.9	9.8
25. Tool & equipment availability	0.9	0.0	13.4	45.5	40.2
26. Forward operating location responsibilities	2.7	12.5	40.2	33.0	11.6
27. Vehicle utilization rates	0.9	8.0	28.6	42.0	20.5

of “Very Great Extent” were parts availability (54.5%), training level of assigned personnel (53.6%), and the budget available for vehicle maintenance (50.9%).

Accordingly, these categories also received the fewest number of ratings (0%) in the “Not At All” category. On the other hand, the factors receiving the most ratings of “Not At All” were availability of warranty service (6.3%), age of maintenance facility (4.5%), and forward operating location responsibilities (2.7%). Mean response rates for all the factors are shown in Table 4.

Table 4. Rank Order of Independent Factors

Performance Measurement Factors	Mean Response Rate
Training Level of Assigned Personnel	4.49
Parts Availability	4.43
Available Manpower	4.43
Budget Available for Vehicle Maintenance	4.37
Tool and Equipment Availability	4.24
Age of Vehicle Fleet	4.11
Experience (# of Years) of Assigned Personnel	4.07
Vehicle Utilization Rates	3.73
Forward Operating Location responsibilities	3.38
Size of Maintenance Facility	3.36
Severity of Climate	3.29
Age of Maintenance Facility	2.96
Availability of Warranty Service	2.89

Table 4 shows that respondents believe training levels of assigned personnel (4.49) affected performance levels of vehicle maintenance units the most. Parts availability (4.43) and available manpower (4.43) were the next two factors impacting performance to the greatest extent. Parts availability was listed first, among the two, because this factor received more ratings in the “Very Great Extent” category (54.5%) when compared to available manpower (47.3%). The lowest rated factors were severity of climate (3.29), age of maintenance facility (2.96), and availability of warranty service (2.89).

Independent Factor Selection

The selection of independent factors for analysis and inclusion for determination of an acceptable vehicle maintenance standard was decided upon through the testing described

in Chapter III. This included Wilcoxon Rank Sum Tests to determine significant differences between independent factor mean ratings. The methodology also included selection of all mean responses falling between ratings of “Great Extent” and “Very Great Extent.” The findings are shown in Table 5. This table indicates there was not a significant difference between mean response rates until the “Experience (# of years) of Assigned Personnel” and “Vehicle Utilization Rates” factors were compared. Because of these results, only the first seven independent factors were considered for further analysis

Table 5. Independent Factor Analysis

Independent Factor	Independent Factor	P-Value	Z-Value	Reject HO:
Training	Parts Availability	0.7508	0.318	No
Parts Availability	Available Manpower	0.6929	0.395	No
Available Manpower	Available Budget	0.8641	0.171	No
Available Budget	Tool & Equipment Availability	0.2092	1.256	No
Tool & Equipment Availability	Age of Vehicle Fleet	0.3335	0.967	No
Age of Vehicle Fleet	Experience Level of Personnel	0.6983	0.388	No
Experience Level of Personnel	Vehicle Utilization Rates	0.0070	2.699	Yes

The results of this testing met the second criteria for inclusion of independent factors for consideration--that of achieving a mean rating of at least 4.0.

Mean Response Results By Subgroups

Demographic data collected from this survey allowed for the comparison of different subgroups and their perceptions about whether or not independent factors should be

considered when establishing a performance standard. This data was also used to discriminate among the independent factor ratings. The subgroups providing insight into various perceptions, as stated in Chapter III, were distinguishable by rank, VMO experience, and whether or not the respondent had vehicle maintenance responsibilities at the time the survey was administered. Breakdowns of these subgroups are in Tables 6 to 11. The mean values of the "0-1 thru 0-2" and "Other" subgroups about the importance of considering independent factors when establishing a performance measurement standard were 6.5 and 6.75 respectively and fell in a range of responses between "Agree" and

Table 6. Rank Subgroup Mean Response vs. Question 14

Rank	Responses	Mean Value
0-1 thru 0-2	6	6.5
0-3	38	5.84
0-4	48	5.96
0-5	12	5.92
Other	8	6.75

"Strongly Agree" on the scale. However, the 0-3, 0-4, and 0-5 subgroup mean responses were 5.84, 5.96, and 5.92 respectively and fell in the range of responses between "Slightly Agree" and "Agree." To help explain this finding, testing was performed to determine why there were differences in perceptions; it was discovered that every respondent in the "0-1 thru 0-2" and "Other" subgroups was currently in a VMO position. To determine the

extent of the subgroups' differences, Wilcoxon Rank Sum Tests were accomplished in a later section.

Analysis of the responses from the second subgroup, VMO experience, was performed to determine if any differences existed among respondents. The results of this analysis are shown in Table 7. There were no noticeable differences in any categories except those from respondents possessing 1-2 years of VMO experience. However, further research

Table 7. VMO Experience vs. Question 14

Experience Level	Responses	Mean Value
None	15	6.1333
Less than one year	7	6.0000
1 but less than 2 years	35	5.7714
2 years or more	55	6.1132

found that of the 35 respondents in this category, only eight currently had VMO responsibilities at the time the survey was administered. Except for respondents with 1-2 years of experience, all other categories had mean responses between "Agree" and "Strongly Agree" (6.1333, 6.0000, 6.1132). The respondents with 1-2 years of VMO experience had a mean response of 5.7714. This response corresponded to a rating between "Slightly Agree" and "Agree." Analyzing the extent of the subgroups' differences required the use of the Wilcoxon Rank Sum Test to determine if there was a statistically significant difference in perception. Results of this test are reported in a later section of this chapter.

Analysis of the third subgroup, whether or not respondents had VMO responsibilities at the time the survey was administered, provided valuable insight into how each group viewed the importance of using independent factors when establishing an acceptable performance measurement standard. Table 8 provides a breakdown of how each category responded. Respondents with VMO responsibilities had a mean response of 6.48

Table 8. VMO Responsibilities vs. Question 14

Vehicle Maintenance Responsibilities	Number of Responses	Mean Value
Yes	25	6.48
No	87	5.86
TOTAL	112	6.00

(between "Agree" and "Strongly Agree"), while respondents that did not have VMO responsibilities had a mean response of 5.86 (between "Slightly Agree" and "Agree"). Analyzing the extent of the subgroups' differences required the use of the Wilcoxon Rank Sum Test to determine if there was a statistically significant difference in perception. Results of this test are reported in a later section of this chapter.

It is apparent from the analysis of the subgroups that a major determinant affecting perceptions about the establishment of performance measurements was whether or not the respondent had vehicle maintenance responsibilities at the time the survey was administered. This conclusion made sense, because a VMO would be more intimately involved with problems encountered when dealing with the VOC performance standard.

Therefore, VMOs would more likely possess a higher mean response when asked to determine if independent factors should be included in a performance measurement system.

In addition to analyzing the relationship between independent factors and the establishment of a performance measurement system, demographic data collected from this survey allowed further analysis of the independent factors presented in questions 15-27. The same subgroups were used to analyze the seven independent factors chosen for further study. Breakdowns of these subgroups are in Tables 9-11. As seen by the mean value responses in table 9, the subgroups perceived each performance measurement factor as impacting vehicle maintenance somewhere between a "Great Extent" and "Very Great Extent" with five exceptions. The 0-1 through 0-2 category perceived the impact of tool and equipment availability and experience (# of years) of assigned personnel quite differently from the majority. The mean responses for these factors were 3.83 and 3.67 respectively and fell between the "Moderate Extent" and "Great Extent" range on the Likert scale. The 0-3 subgroup perceived the impact of age of the vehicle fleet and

Table 9. Mean Response of Rank Subgroup vs. Performance Factors

Performance Measurement Factors	0-1/0-2	0-3	0-4	0-5	Other
Training Level of Assigned Personnel	4.50	4.50	4.46	4.50	4.63
Parts Availability	4.17	4.47	4.33	4.67	4.63
Available Manpower	4.17	4.39	4.48	4.25	4.75
Budget Available for Vehicle Maintenance	4.83	4.34	4.31	4.17	4.75
Tool and Equipment Availability	3.83	4.34	4.17	4.17	4.63
Age of Vehicle Fleet	4.50	3.87	4.29	4.17	3.75
Experience (# of Years) of Assigned Personnel	3.67	3.95	4.10	4.25	4.50

experience (# of years) of assigned personnel differently from the majority. The mean responses for these factors are 3.87 and 3.95 respectively and fall between the Moderate and Great Extent range on the Likert scale. The other subgroup's mean response for age of vehicle fleet is 3.75. Both of these ratings indicate a difference in perceptions and fall between the "Moderate" and "Great Extent" range on the Likert scale.

Table 10 displays the mean responses of the VMO experience subgroups in relation to each independent factor. The mean value responses indicate that the majority of subgroups perceive each performance measurement factor as impacting vehicle

Table 10. Mean Response of Experience Subgroup vs. Performance Factors

Performance Measurement Factors	None	<1 yr.	1-2 yrs	>2 yrs
Training Level of Assigned Personnel	4.73	4.44	4.43	4.47
Parts Availability	4.40	4.33	4.29	4.55
Available Manpower	4.67	4.11	4.31	4.49
Budget Available for Vehicle Maintenance	4.40	4.33	4.37	4.36
Tool and Equipment Availability	4.53	4.00	4.06	4.32
Age of Vehicle Fleet	3.93	4.67	4.03	4.11
Experience (# of Years) of Assigned Personnel	4.27	3.11	4.14	4.13

maintenance somewhere between a "Great Extent" and "Very Great Extent." However, there is some disagreement among the subgroups as to how they perceive the impact of age of vehicle fleet and experience (# of years) of assigned personnel. Personnel with greater than zero but less than one year experience perceived experience (# of years) of assigned personnel as having less impact on vehicle maintenance performance than the

other subgroups. The mean response for this factor was 3.11 and corresponded to a rating between “Moderate Extent” and “Great Extent” on the Likert scale. The zero year subgroup perceived age of the vehicle fleet differently than the majority. The mean response was 3.93 and fell between “Moderate Extent” and “Great Extent” on the Likert scale. Further analysis of these subgroups to determine if the differences in perceptions are statistically significant will be accomplished in the next section.

The final discriminating characteristic is personnel with VMO responsibilities compared to personnel without VMO responsibilities at the time the survey was administered. Table 11 displays the results of this comparison. Both subgroups agreed on every performance factor. Mean responses were between 4.01 and 4.52 and represent a rating between ranges of “Great Extent” and “Very Great Extent” on the Likert scale

Table 11. Mean Response of VMO Responsibilities vs. Performance Factors

Performance Measurement Factors	No VMO	Yes VMO
Training Level of Assigned Personnel	4.48	4.52
Parts Availability	4.41	4.48
Available Manpower	4.43	4.44
Budget Available for Vehicle Maintenance	4.34	4.44
Tool and Equipment Availability	4.23	4.28
Age of Vehicle Fleet	4.10	4.12
Experience (# of Years) of Assigned Personnel	4.01	4.28

Wilcoxon Rank Sum Tests for Selected Subgroups And Performance Factors

This section determines if the differences in perceptions of the various subgroups identified in the previous section are statistically significant. If the differences in perceptions of the subgroups were determined to be statistically significant, an explanation of the differences is offered in the next section by the research team.

When asking whether or not independent factors should be considered when establishing a performance standard, the rank subgroups of 0-1/0-2 and others differed in mean response from the 0-3, 0-4, and 0-5 subgroups. Accordingly, a Wilcoxon Rank Sum Test was performed and a z statistic and corresponding p-value were calculated as 2.04 and .041 respectively. These values led to the rejection of the null hypothesis and a conclusion that the two subgroups have different mean responses.

The VMO experience subgroups of 1-2 years of experience differed in mean response from the none, less than one, and two or more years of experience subgroups. The results of the Wilcoxon Rank Sum Test, 1.186 for a z statistic and .2355 for a p value, led to the non-rejection of the null hypothesis and the conclusion that the two subgroups have the same mean responses.

Analysis of data from respondents currently serving in a position with vehicle maintenance responsibilities shows a significant difference between those respondents that do not currently have those same responsibilities. The Wilcoxon Rank Sum Test resulted in a z statistic of 2.14 and a p-value of .032. This result led to the rejection of the null hypothesis, and a conclusion that each sample population has different perceptions about

whether independent factors should be considered when establishing an acceptable performance measurement standard.

There were disagreements between subgroups when asking what independent factors impact vehicle maintenance the most. Table 12 displays the independent factors and the subgroups that needed to be tested.

Table 12. Subgroups For Testing Corresponding Factors

Performance Measurement Factors	Subgroup 1	Subgroup 2
1. Tool and Equipment Availability	0-1 thru 0-2	All others
2. Age of Vehicle Fleet	0-1/0-2/0-4/0-5	0-3/Other
3. Age of Vehicle Fleet	No experience	Some Experience
4. Experience (# of Years) of Assigned Personnel	Less than 1 Year	All others
5. Experience (# of Years) of Assigned Personnel	0-1/0-2/0-3	0-4-other

Five tests were needed, and the factors disagreed upon the most were experience (# of years) of assigned personnel and age of the vehicle fleet. Wilcoxon Rank Sum Tests were performed to determine if these responses were significantly different in mean responses between subgroups. The results of the tests led to the rejection of the null hypothesis (subgroup mean responses were equal) on two occasions. The test results are shown in Table 13.

The two tests resulting in significantly different perceptions of subgroups corresponded to the age of vehicle fleet and experience of assigned personnel. For the age of the vehicle

fleet factor, the subgroup of 0-1/0-2/0-4/0-5 differed from the respondents that were 0-3/Others. The experience (# of years) of assigned personnel factor differed significantly

Table 13. Results of Wilcoxon Rank Sum Tests

Performance Measurement Factors	z statistic	p-value	reject H ₀
1. Tool and Equipment Availability	1.157	.2475	No
2. Age of Vehicle Fleet	2.280	.0226	Yes
3. Age of Vehicle Fleet	.0540	.9569	No
4. Experience (# of years) of Assigned Personnel	2.788	.0053	Yes
5. Experience (# of years) of Assigned Personnel	1.159	.2466	No

between the less than one year subgroup (VMO experience) and the zero, one, and two or more year subgroup.

Explanation Of Significantly Different Perceptions

There were four significantly different mean responses between subgroups. The first significant difference in perceptions occurred between the 0-1/0-2/others subgroup and 0-3/0-4/0-5 subgroup. This difference corresponded to whether or not independent factors should be considered when establishing a performance standard. The first subgroup placed more importance on including independent factors when compared to the second subgroup. As stated earlier, further analysis of the first subgroup revealed that every single respondent in the first subgroup was currently in a position that had VMO responsibilities at the time the survey was administered. This realization implied that

respondents with VMO responsibilities recognized the importance of independent factors that impact vehicle maintenance performance and, at the time, were more intimately involved with the VOC standard than the rest of the respondents. Respondents with VMO responsibilities were more aware of the importance of independent factors because they were subject to the daily demands, conditions, and requirements associated with the factors that impact vehicle maintenance. For example, on a daily basis a VMO had to be aware of budget levels, manpower requirements, and training demands placed on his or her operation. Respondents without VMO responsibilities were, in most cases, much farther removed from the unique daily demands placed on VMOs. Another reason for this difference was that, for the most part, respondents with VMO responsibilities were located at the squadron level where performance measurement was an important concept in the TQM movement in the Air Force. Personnel subject to TQM had received training on the importance of establishing performance measures.

The second significant difference in perceptions occurred between the respondents with VMO responsibilities subgroup and the respondents without VMO responsibilities subgroup. This difference corresponded to whether or not independent factors should be considered when establishing a performance standard. The first subgroup placed more importance on including independent factors when compared to the second subgroup. As stated in the previous paragraph, this difference in perception should have been expected because of the above-mentioned reasons.

The third significant difference in perceptions occurred among the respondents with less than one year experience as a VMO and the subgroup of respondents with none, one, or two or more years of experience as a VMO. The latter group had a higher mean response for the impact of experience (# of years) of assigned personnel on vehicle maintenance performance. In-depth analysis of this difference in responses resulted in the discovery of a significant difference between mean values based on rank. The less than one year subgroup consisted of nine respondents. Five of these respondents were majors and the remaining four were split evenly between captains and lieutenants. The mean response rates for majors were 3.8 and the captains and lieutenants were 2.25 indicating a difference in perception based on time in the service. Majors, for the most part, have between 11 and 15 years of service, whereas captains and lieutenants have much less service time. Because of this increased time in the service, majors have significantly more knowledge and experience in transportation related matters than lieutenants and captains.

The last significant difference in perceptions occurred among the 0-1/0-2/0-4/0-5 subgroup and 0-3/Other subgroup. This difference corresponded to the impact of the age of vehicle fleet factor. The former group had a higher mean response for the impact of age of vehicle fleet on vehicle maintenance performance. Further analysis of this difference in mean response ratings revealed that 16 respondents in the 0-1/0-2/0-4/0-5 subgroup (24.25%) were currently serving in positions with vehicle maintenance responsibilities while only nine respondents (19.56%) in the 0-3/Other subgroup were in similar positions. Furthermore, the 0-1/0-2/0-4/0-5 subgroup averaged between one and

two years of VMO experience and the 0-3/Other subgroups averaged one year or less of VMO experience. These results lead to the conclusion that increased experience, knowledge, and time in the Air Force lead to increased emphasis on independent factors affecting performance levels of vehicle maintenance units.

Examination Of Comments From Survey Respondents

The main purpose of section III, question 28, was to obtain additional information about factors impacting the performance of vehicle maintenance units. This section was included because the researchers realized that there might be additional independent factors that were not included in the survey. This open-ended question also provided a forum for transportation officers to voice any additional comments they might have.

Of the 112 surveys returned, 44 of them contained responses to question 28. Basically, there were two types of responses. The first type provided additional factors that impact vehicle maintenance performance not contained in questions 15-27. The factors appearing the most were: types of Wing mission, types of customers, deployment taskings, fleet composition, accident and abuse rates, additional duties, condition of the maintenance facility, structure and layout of the maintenance facility, time to order and receive parts, availability of commercial services and vendors, and strength of the Vehicle Control Officer (VCO) program. After reviewing these responses, the research team decided that the responses with no overlap with any of the factors already in the survey would be considered for future analysis. Based on this criteria, strength of the VCO

program, fleet composition, and availability of commercial services and vendors should be studied in future research efforts. These three responses were prevalent throughout the survey responses for question 28.

The second type of response described various types of performance standards that respondents perceived as adequate or wished to implement in the future. The only standard mentioned as adequate was the percent of vehicles returned from maintenance within eight hours. The researchers were unable to locate this standard in any vehicle maintenance regulation, leading to the conclusion that this standard is a newly adopted one implemented under the TQ philosophy. Without additional information about this standard, no analysis or conclusions can be made about the adequacy of the standard.

Respondents also suggested performance standards they would like to see implemented. One respondent wanted to create a performance standard that ties vehicle procurement, vehicle services, and mission together. Another respondent wanted to create a performance standard relating to vehicle mission essential levels.

Summary

This chapter presented the results and analysis of the data used to answer investigative questions three, four, six, seven, and eight. The large amount of data collected from the survey indicated that the current VOC performance standard was not considered an adequate performance measure. The respondents overwhelmingly agreed that independent factors need to be included when determining vehicle maintenance

performance. The independent factors chosen most important by the respondents were training levels of assigned personnel, parts availability, available manpower, budget available for vehicle maintenance, tool and equipment availability, age of vehicle fleet, and experience (# of years) of assigned personnel. The only difference in perceptions, based on rank, vehicle maintenance experience, and current responsibilities, occurred at question 14 (whether or not independent factors should be considered when establishing a performance standard), question 17 (experience (# of years) of assigned personnel), and question 19 (age of the vehicle fleet). Conclusions and recommendations based on this analysis are presented in Chapter V.

V. Conclusions And Recommendations

Introduction

The purpose of this chapter is to discuss the conclusions and recommendations of this research effort. First, answers are provided to the investigative questions which, when taken as a whole, provide the basis for answering the research question. Next, we examine the conclusions and recommendations of this research based on research into prior studies and results of a mail survey. Finally, recommendations for future research are provided.

Investigative Questions Answered

This section provides answers to investigative questions stated in Chapter I that determine the most appropriate performance measurement system for Air Force vehicle maintenance units.

Investigative Question 1. *How are efficiency, effectiveness, and productivity related to performance measurement?*

The literature review examined the essential characteristics of a performance measurement system and determined that the important concepts of any performance measurement system are productivity, efficiency, and effectiveness. Productivity was defined as both a measure of effectiveness and efficiency. Effectiveness is achieving both

customer satisfaction and organizational goals and efficiency is the ratio of inputs consumed to outputs produced.

Investigative Question 2. *Why are more relevant performance measurement indicators needed in government organizations?*

Examination of previous studies and literature indicated that government organizations do not utilize adequate performance measurement systems. It was determined that essential characteristics of an effective performance measurement system were missing in performance measures of government organizations.

Investigative Question 3. *How do vehicle maintenance officers perceive the VOC performance standard?*

The literature review uncovered previous research by Weisert and Clark (1972) and Brewer (1989), indicating the inadequacy of current transportation performance measurements. Comparison of units using VOC measurements was not accurate and the research concluded it should not be used to cross-compare units. The results of our research supported these conclusions. Although vehicle maintenance units were subject to VOC standards, a large majority of respondents, 88.4 percent, perceived the VOC standard as inadequate.

Investigative Question 4. *Should independent factors be included when establishing a performance standard?*

This question was answered based on results of the literature review and the survey questionnaire. The literature review stressed the importance of including independent

factors that impact performance when establishing a performance measurement system. In addition, results of our research indicated that nearly 89 percent of respondents believe independent factors should be included when establishing a performance standard.

Investigative Question 5. *Is multiple regression analysis suitable for evaluating the performance of vehicle maintenance units?*

The answer to this question is found in the section entitled Performance Measurement Systems for Vehicle Maintenance located in chapter two. This section examined the benefits of how a regression model can help evaluate performance of Air Force aircraft maintenance units and the U.S. Postal Service. This section concluded that regression models were suitable for service organizations desiring to measure the effect of both quantifiable and intangible factors that effect performance and cross-compare units. Because vehicle maintenance units are a service organization located in many unique geographic areas, and experience many of the same type conditions as aircraft maintenance units, regression analysis should be used to evaluate the performance.

Investigative Question 6. *What independent variables impact the performance of vehicle maintenance units the most?*

Because the literature review stressed the importance of limiting the number of required performance measures to a minimum, the researchers decided to focus on independent variables impacting vehicle maintenance units the most. The variables meeting this criteria were training level of assigned personnel, parts availability, available

manpower, budget available for vehicle maintenance, tool and equipment availability, age of vehicle fleet, and experience (# of years) of assigned personnel.

Investigative Question 7. *Are there differences in perceptions, based on rank, transportation experience, and current position, about the VOC standard?*

The mean response results of this analysis can be found in Tables 5-7. The results indicated a difference in perception based on rank, transportation experience, and current position. However, Wilcoxon Rank Sum Testing revealed that differences in perceptions about a performance measurement standard occurred between the rank groups of (0-1/0-2/and others) and the rank group of (0-3/0-4/and 0-5). Additionally, this same procedure revealed that a difference in perceptions existed between respondents currently serving in positions with vehicle maintenance responsibilities and those respondents that did not currently have those same responsibilities.

Investigative Question 8. *Are there differences in perceptions, based on rank, transportation experience, and current position, about the most important independent variables impacting vehicle maintenance performance?*

The mean response results for this analysis can be found in Tables 8-10. There appear to be five differences in perceptions (Table 11). However, a Wilcoxon Rank Sum Test revealed that there were only two statistically significant different mean responses, that corresponded to the age of vehicle fleet and experience (# of years) of assigned personnel. For the age of the vehicle fleet factor, the subgroup of 0-1/0-2/0-4/0-5 differed from the respondents that were in the 0-3/others subgroup. Finally, the experience (# of years) of

assigned personnel factor differed significantly between the less than one year VMO experience subgroup and the all other subgroup.

Conclusions And Recommendations

Many conclusions could be reached from the results of this research effort. The most significant conclusion was that the VOC standard was not viewed as an adequate performance indicator for vehicle maintenance units. Although this measure was used to compare vehicle maintenance performance at different locations, the results of this research indicated that this comparison was inadequate because the VOC measure did not account for independent factors that impact performance. Additionally, it was determined that the current VOC measure was not established using the concepts of productivity, effectiveness, and efficiency.

Another important conclusion was that of placing emphasis on a performance measurement system that incorporates the use of independent factors. To allow cross-comparison of vehicle maintenance units, independent factors should be included in the performance measurement standard to account for the specific operating conditions at different locations. In keeping with the concept of limiting the number of measures to less than 15, this research identified the seven most important factors impacting vehicle maintenance units.

Another conclusion relates to the type of performance measurement system compatible with vehicle maintenance operations. Results indicated that the best possible performance

measurement standard should employ multiple regression analysis techniques. Using this technique, vehicle maintenance units will be able to examine the effects of the independent factors on performance and use this analysis to improve the decision-making process. In addition, VMOs will be able to identify areas of strong and weak performance in a timely manner without having to conduct time-consuming research.

The final conclusion was based on perceptions of vehicle maintenance officers. VMOs and respondents with one or greater years of total time in service or vehicle maintenance experience perceived that independent factors impacted vehicle maintenance performance more than respondents who were not VMOs or had little or no experience. This realization led to the conclusion that personnel with VMO responsibilities, or a great amount of experience, were more knowledgeable about the factors impacting vehicle maintenance performance levels and, therefore, perceived independent factors as being more important in a performance measurement system.

From these conclusions, a number of recommendations can be made. First and foremost, the current VOC standard should be eliminated and a new standard established which utilizes regression analysis and the seven independent factors identified in this research.

If this is not possible, and the VOC standard continues to be utilized, a survey of vehicle maintenance customers should be performed to determine an accurate and effective customer service level. This procedure would incorporate the concept of effectiveness into the VOC standard. To introduce the concept of efficiency, without

using independent factors and regression analysis techniques, however, would be beyond the capabilities of current management systems. Although these two recommendations would not result in the best solution, the new standard would still be an improvement over the current VOC standard.

Recommendations For Future Research

Several aspects of this topic warrant further research. These areas include:

1. Determine the optimal method of measuring the seven independent factors identified in this research so that regression analysis can be performed. Constraints to consider when measuring these factors include ease of measurement, economic considerations, and the use of existing data retrieval systems. This research would involve a study to establish a regression analysis formula using the seven independent factors identified in this research. Historical data representing the factors could be used to validate the regression model.

2. Identify specific customer requirements, varying by location, that can also be included in the multiple regression formula.

Based on responses to question 28, additional research could be conducted that includes the following:

1. Determine the strength of the VCO program, availability of commercial services and vendors, and whether or not fleet composition is considered important enough to include in a regression model.

2. Evaluate the "percent of vehicles returned from maintenance within eight hours" performance standard to determine if this standard is also suitable for evaluating vehicle maintenance performance.

3. Conduct research into the implications of adopting a performance standard that is based on vehicle mission essential levels.

Summary

This research examined the adequacy of the VOC standard used to evaluate vehicle maintenance performance throughout the Air Force. We reviewed literature on the concepts of a good performance measurement system and related these concepts to the VOC standard. Through the use of a mail survey, the inadequacy of the current VOC standard and the importance of including independent factors in a vehicle maintenance performance standard were identified. By using mean response rates and Wilcoxon Rank Sum Testing, seven independent factors were identified that impact vehicle maintenance the most. Based on these results, conclusions, recommendations, and areas for future research were presented.

Appendix A: Operating Efficiency Formula

$$\text{OPERATING EFFICIENCY} = a_1 * F_1 + a_2 * F_2 + a_3 * F_3 + a_4 * F_4 + a_5 * F_i \dots + a_{12} * (F_1 * F_2) + \dots$$

where F_i are factors that influence operating efficiency, and a_i are coefficients that quantify effects of changes in these factors.

The equation and factors used to measure the level of operating efficiency at mail processing facilities is shown below.

$$\begin{aligned} \text{OE} = & \beta_1 \text{PVOL} + \beta_2 \text{PVOL}^2 + \beta_3 \text{SBVOL} + \beta_4 \text{DVOL} + \beta_5 \text{ITVOL} + \beta_6 \text{HR} + \\ & \beta_7 \text{HR}^2 + \beta_8 \text{HR}^2 * \text{VOL} + \beta_9 \text{PS} + \beta_{10} \text{PS}^2 + \beta_{11} \text{YR} + \beta_{12} \text{YR} * \text{MPF} + \\ & \beta_{13} \text{PA}^2 * \text{LVOL} + \beta_{14} \text{PA} * \text{LVOL} * \text{MPF} + \beta_{15} \text{PA} * \text{VOLFT} + \beta_{16} \text{PA}^2 * \text{FR} + \\ & \beta_{17} \text{PA}^2 * \text{FR}^2 + \beta_{18} \text{VOL} * \text{FR} + \beta_{19} \text{NSUB} + \beta_{20} \text{DELS} + \beta_{21} \text{RTS}^2 + \\ & \beta_{22} \text{NSUB} * \text{DVOL} + \beta_{23} \text{RTS} * \text{DVOL} + \beta_{24} \text{RTS} * \text{NSUB} + \beta_{25} \text{RTS} * \text{DELS} + \\ & \beta_{26} \text{DELS} * \text{DVOL}, \end{aligned}$$

where:

PVOL = the volume of mail processed;
 SBVOL = the volume of mail processed at stations and branches;
 DVO = the volume of mail delivered;
 ITVO = the volume of incoming tertiary mail processed;
 HR = the proportion of labor in human resource functions;
 PS = the square footage of mail processing space;
 YR = the age of the facility;
 MPF = the floors of the facility dedicated to mail processing;
 PA = the percentage of letter volume processed on automated equipment;
 LVOL = the volume of letters processed;
 VOLFT = the volume of mail processed per square foot of space;
 FR = the proportion of workforce made up of flexible (part-time) labor;
 NSUB = the number of sub-locations for ancillary processing and delivery;
 DELS = the number of delivery points;
 RTS = the number of letter carrier routes

Appendix B: Pilot Survey

Vehicle Maintenance Performance Measurement Survey (Pilot Study)

This survey is designed to gather data based on your opinions and experiences within the vehicle maintenance field. Please read each question carefully and follow the instructions provided above each set of questions. Use a soft lead pencil (#2) to mark your responses on the attached scan sheet. If you answer any of the questions with an "Other" response, please fill in the appropriate response in the space provided on the questionnaire. When you have completed the survey, please enclose the questionnaire and survey scan sheet in the enclosed pre-addressed envelope and put it in the mail. If possible, please respond within one week of receiving this survey. Thank you for your cooperation and assistance.

Background Information

Please circle the appropriate response. If you answer any of the questions with an "Other" response, please fill in the appropriate information in the space provided.

1. What is your present rank?
1. 0-1 thru 0-2 2. 0-3 3. 0-4 4. 0-5 5. 0-6 6. Other _____
2. What is your primary AFSC?
1. 24T1 2. 24T3 3. 24T4 4. Other _____
3. What is your duty AFSC?
1. 24T1 2. 24T3 3. 24T4 4. Other _____
4. At what level are you currently performing your duties?
1. Base/Wing-level 2. Staff-level 3. Other _____
5. What command are you currently assigned to?
1. ACC 2. AMC 3. AFMC 4. PACAF 5. USAFE 6. Other _____
6. How much experience have you had as a vehicle maintenance officer?
1. None 2. Less than 1 year 3. 1-2 years 4. More than 2 years
7. Are you currently serving as a vehicle maintenance officer? *If you answer No to this question, go directly to question 14. (skip questions 8 through 13)*
1. Yes 2. No
8. Are you subject to vehicle out-of-commission (VOC) standards from your MAJCOM?
1. Yes 2. No

9. Are you subject to VOC standards from your base or unit?
1. Yes 2. No
10. If you answered yes to question 9, are these standards different from your MAJCOM standard?
1. Yes 2. No
11. If you are subject to VOC standards, what is your current standard?
1. more than 10% 2. 10% 3. 9% 4. 8% 5. Less than 8%
12. Are you required to brief or report your VOC results on a regular basis?
1. Yes 2. No
13. If you answered yes to question 12, who is briefed about your VOC rates (*circle all that apply*)
1. MAJCOM 2. Wing-level 3. Group-level 4. Unit-level

Vehicle Maintenance Performance Measurement Factors

14. When manpower levels are established, various factors are used to determine what these levels should be. Do you think these type of factors, such as available manpower, age of vehicle fleet, budget levels, etc., should be considered when establishing an acceptable vehicle maintenance performance standard?
1. Yes 2. No

Using the scale below, please rate each independent factor as you perceive the performance level of a vehicle maintenance unit being affected and circle your response.

	Not Affected	Mildly Affected	Somewhat Affected	Affected	Substantially Affected	Highly Affected	Extremely Affected
	1-----	2-----	3-----	4-----	5-----	6-----	7-----
15. Available Manpower					1 2 3 4 5 6 7		
16. Training level of assigned personnel					1 2 3 4 5 6 7		
17. Experience (# of years) of assigned personnel					1 2 3 4 5 6 7		
18. Budget available for vehicle maintenance					1 2 3 4 5 6 7		
19. Age of vehicle fleet					1 2 3 4 5 6 7		

Vehicle Maintenance Performance Measurement Factors (Continued)

Using the scale below, please rate each independent factor as you perceive the performance level of a vehicle maintenance unit being affected and circle your response.

	Not Affected	Mildly Affected	Somewhat Affected	Affected	Substantially Affected	Highly Affected	Extremely Affected
	1	2	3	4	5	6	7
20. Parts availability					1 2 3 4 5 6 7		
21. Severity of climate					1 2 3 4 5 6 7		
22. Availability of warranty service					1 2 3 4 5 6 7		
23. Age of maintenance facility					1 2 3 4 5 6 7		
24. Size of maintenance facility					1 2 3 4 5 6 7		
25. Tool & equipment availability					1 2 3 4 5 6 7		
26. Forward operating location responsibilities					1 2 3 4 5 6 7		
27. Vehicle utilization rates					1 2 3 4 5 6 7		

Identification Of Other Performance Factors

28. Are there other factors that should be considered when determining performance levels of vehicle maintenance units that are not listed above? Please respond below.

Appendix C: Pilot Survey Correlation Analysis

13 'VAR' Variables: PERF1 PERF2 PERF3 PERF4 PERF5 PERF6
 PERF7 PERF8 PERF9 PERF10 PERF11 PERF12
 PERF13

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
PERF1	10	5.70000	0.94868	57.00000	4.00000	7.00000
PERF2	10	5.30000	0.94868	53.00000	4.00000	7.00000
PERF3	10	4.60000	0.96609	46.00000	3.00000	6.00000
PERF4	10	4.70000	1.05935	47.00000	3.00000	6.00000
PERF5	10	5.20000	1.31656	52.00000	3.00000	7.00000
PERF6	10	5.10000	0.99443	51.00000	4.00000	7.00000
PERF7	10	4.60000	1.17379	46.00000	2.00000	6.00000
PERF8	10	3.70000	0.94868	37.00000	2.00000	5.00000
PERF9	10	2.70000	1.05935	27.00000	1.00000	4.00000
PERF10	10	3.40000	1.42984	34.00000	1.00000	6.00000
PERF11	10	5.60000	0.84327	56.00000	5.00000	7.00000
PERF12	10	3.90000	1.72884	39.00000	1.00000	7.00000
PERF13	10	4.20000	1.98886	42.00000	1.00000	7.00000

Cronbach Coefficient Alpha for RAW variables: 0.845914
 for STANDARDIZED variables: 0.845233

Deleted Variable	Raw Variables		Std. Variables	
	Correlation with Total	Alpha	Correlation with Total	Alpha
PERF1	0.000000	0.860455	0.074405	0.861345
PERF2	0.632813	0.829178	0.587601	0.828309
PERF3	0.372673	0.842513	0.406616	0.840458
PERF4	0.482133	0.836465	0.470997	0.836200
PERF5	0.533027	0.832767	0.590484	0.828111
PERF6	0.585191	0.831154	0.587563	0.828312
PERF7	0.451597	0.838169	0.465492	0.836567
PERF8	0.664016	0.827532	0.658264	0.823413
PERF9	0.582755	0.830649	0.545141	0.831209
PERF10	0.869284	0.805268	0.826615	0.811396
PERF11	0.204744	0.849975	0.224340	0.852139
PERF12	0.481159	0.840214	0.428168	0.839040
PERF13	0.700466	0.821278	0.655259	0.823623

Pilot Survey Correlation Analysis (continued)

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 10

	PERF1	PERF2	PERF3	PERF4	PERF5	PERF6	PERF7
PERF1	0.00000 0.0	0.11111 0.7599	0.33945 0.3373	0.01106 0.9758	0.40922 0.2403	0.15311 0.6728	-0.01996 0.9564
PERF2	0.11111 0.7599	1.00000 0.0	0.26671 0.4563	0.09950 0.7845	0.12454 0.7317	0.67133 0.0335	0.21952 0.5423
PERF3	0.33945 0.3373	0.26671 0.4563	1.00000 0.0	0.52112 0.1224	0.50667 0.1350	0.16192 0.6549	0.13718 0.7055
PERF4	0.01106 0.9758	0.09950 0.7845	0.52112 0.1224	1.00000 0.0	0.28680 0.4217	0.03164 0.9309	-0.10723 0.7681
PERF5	0.40922 0.2403	0.12454 0.7317	0.50667 0.1350	0.28680 0.4217	1.00000 0.0	0.49223 0.1484	0.63272 0.0496
PERF6	0.15311 0.6728	0.67133 0.0335	0.16192 0.6549	0.03164 0.9309	0.49223 0.1484	1.00000 0.0	0.51403 0.1285
PERF7	-0.01996 0.9564	0.21952 0.5423	0.13718 0.7055	-0.10723 0.7681	0.63272 0.0496	0.51403 0.1285	1.00000 0.0
PERF8	0.13580 0.7084	0.48148 0.1588	0.09699 0.7898	0.45329 0.1883	0.32026 0.3670	0.38867 0.2670	0.47895 0.1614
PERF9	-0.21006 0.5602	0.21006 0.5602	0.62969 0.0511	0.70297 0.0234	0.60547 0.0636	0.34806 0.3243	0.25020 0.4857
PERF10	-0.14744 0.6844	0.72083 0.0187	0.20913 0.5620	0.45480 0.1866	0.30692 0.3884	0.51575 0.1270	0.50315 0.1382
PERF11	0.38889 0.2667	0.02778 0.9393	-0.08183 0.8222	0.09950 0.7845	0.18014 0.6185	0.18550 0.6079	0.38166 0.2765
PERF12	-0.29131 0.4141	0.42680 0.2187	0.10644 0.7698	0.52782 0.1169	0.10740 0.7678	0.13572 0.7085	-0.02190 0.9521
PERF13	-0.31800 0.3706	0.78911 0.0067	0.04626 0.8990	0.29533 0.4074	0.19520 0.5889	0.55056 0.0991	0.37124 0.2909

Pilot Survey Correlation Analysis (continued)

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 10

	PERF8	PERF9	PERF10	PERF11	PERF12	PERF13
PERF1	0.13580	-0.21006	-0.14744	0.38889	-0.29131	-0.31800
	0.7084	0.5602	0.6844	0.2667	0.4141	0.3706
PERF2	0.48148	0.21006	0.72083	0.02778	0.42680	0.78911
	0.1588	0.5602	0.0187	0.9393	0.2187	0.0067
PERF3	0.09699	0.62969	0.20913	-0.08183	0.10644	0.04626
	0.7898	0.0511	0.5620	0.8222	0.7698	0.8990
PERF4	0.45329	0.70297	0.45480	0.09950	0.52782	0.29533
	0.1883	0.0234	0.1866	0.7845	0.1169	0.4074
PERF5	0.32026	0.60547	0.30692	0.18014	0.10740	0.19520
	0.3670	0.0636	0.3884	0.6185	0.7678	0.5889
PERF6	0.38867	0.34806	0.51575	0.18550	0.13572	0.55056
	0.2670	0.3243	0.1270	0.6079	0.7085	0.0991
PERF7	0.47895	0.25020	0.50315	0.38166	-0.02190	0.37124
	0.1614	0.4857	0.1382	0.2765	0.9521	0.2909
PERF8	1.00000	0.23218	0.75359	0.38889	0.25066	0.62422
	0.0	0.5186	0.0118	0.2667	0.4849	0.0537
PERF9	0.23218	1.00000	0.45480	-0.27364	0.46715	0.45354
	0.5186	0.0	0.1866	0.4443	0.1734	0.1880
PERF10	0.75359	0.45480	1.00000	0.33174	0.64726	0.90647
	0.0118	0.1866	0.0	0.3490	0.0431	0.0003
PERF11	0.38889	-0.27364	0.33174	1.00000	0.04573	-0.01325
	0.2667	0.4443	0.3490	0.0	0.9002	0.9710
PERF12	0.25066	0.46715	0.64726	0.04573	1.00000	0.68507
	0.4849	0.1734	0.0431	0.9002	0.0	0.0288
PERF13	0.62422	0.45354	0.90647	-0.01325	0.68507	1.00000
	0.0537	0.1880	0.0003	0.9710	0.0288	0.0

Appendix D: Approval Notification Letter

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE MILITARY PERSONNEL CENTER
RANDOLPH AIR FORCE BASE TEXAS

MEMORANDUM FOR AFIT/XP
ATTN: MS HOUTZ

13 APR 1995

FROM: AFMPC/DPMYMS
550 C Street West, Ste 35
Randolph AFB TX 78150-4737

SUBJECT: Request for Survey Approval (Your FAX, 11 Apr 95)

The proposed survey submitted on behalf of Captains Arzberger and Audet is approved contingent on making the following changes:

- a. Reference item 4. Change item to read, "At what organizational level are you currently performing your duties?"
- b. Reference item 5. Change item to read, "To which command are you assigned?"
- c. Reference item 6. Change response option 3 and 4 to read, "3. 1 but less than 2 years, 4. 2 years or more."
- d. Reference scale for item 14. Change to "Strongly Disagree, Disagree, Slightly Disagree, Neutral, Slightly Agree, Agree, Strongly Agree."
- e. Reference items 15 - 27. The item stem and the scale do not match. Please change the stem to read, "To what extent do you believe each of the following independent factors impact the performance level of a vehicle maintenance unit. Please circle your response for each factor." Change the scale to read, "Very Great Extent, Great Extent, Moderate Extent, Slight Extent, Not At All."

Please forward a revised copy of this survey for our files. A survey control number (SCN) of SCN USAF 95-38 is assigned and expires on 1 Sep 95. Questions regarding this action can be addressed to me at DSN 487-5680.

original signed
CHARLES H. HAMILTON
Chief, Survey Branch

Appendix E: Performance Measurement Survey

FROM: Lieutenant Colonel Floyd R. Anible
Air Force Institute of Technology (AFIT/LSM)
Wright-Patterson AFB, OH 45433-7765

19 May 1995

SUBJ: Vehicle Maintenance Performance Measurement Survey

TO: Survey Participants

1. The attached questionnaire was prepared by a research team at the Air Force Institute of Technology, Wright-Patterson AFB OH and is sponsored by the Pacific Air Forces. This survey is designed to gather data, based on your opinions, perceptions, and experiences and those of your fellow transportation maintenance officers, concerning the current vehicle out-of-commission (VOC) standard and the importance of independent factors that affect the performance of vehicle maintenance flights.
2. The goal of this study is to evaluate the current VOC standard and recommend a new performance measurement standard that is based on efficiency, effectiveness, and productivity. The report will be reviewed by managers at every level of the transportation and logistics command structure. Your individual responses will, of course, be kept strictly confidential and will be combined with others to form the basis for this report. Although your participation in this survey is voluntary, we strongly urge you to complete the attached questionnaire and return it as soon as possible. The questionnaire should only take about 20 minutes. This research is for your benefit, and represents an opportunity to make your voice heard in choosing appropriate measures of your performance.
3. Thank you for your cooperation and assistance in this endeavor. If you have any questions or recommendations regarding this survey, please contact Captain Christopher Arzberger at DSN 785-7777, ext. 2105 or Captain Larry Audet at DSN 785-7777, ext. 2107.

original signed

Floyd R. Anible, Lieutenant Colonel, USAF
Deputy Head, Department of Logistics Management
School of Systems and Logistics
Air Force Institute of Technology

Vehicle Maintenance Performance Measurement Survey

This survey is designed to gather data based on your opinions and experiences within the vehicle maintenance field. Please read each question carefully and follow the instructions provided above each set of questions. Use a soft lead pencil (#2) to mark your response on the attached scan sheet. If you answer any of the questions with an "Other" response, please fill in the appropriate information in the space provided on the questionnaire. When you have completed the survey, please enclose the questionnaire and survey scan sheet in the enclosed pre-addressed stamped envelope and put it in the mail. If possible, please respond within one week of receiving this survey. Thank you for your cooperation and assistance.

Background Information

Please mark your response on the scan sheet provided. If you answer any of the questions with an "Other" response, fill in the appropriate information in the space provided on the questionnaire.

1. What is your present rank?
1. 0-1 thru 0-2 2. 0-3 3. 0-4 4. 0-5 5. 0-6 6. Other _____
2. What is your primary AFSC?
1. 24T1 2. 24T3 3. 24T4 4. Other _____
3. What is your duty AFSC?
1. 24T1 2. 24T3 3. 24T4 4. Other _____
4. At what organizational level are you currently performing your duties?
1. Base/Wing-level 2. Staff-level 3. Other _____
5. To which command are you assigned?
1. ACC 2. AMC 3. AFMC 4. PACAF 5. USAFE 6. Other _____
6. How much experience have you had as a vehicle maintenance officer?
1. None 2. Less than 1 year 3. 1 but less than 2 years 4. 2 years or more
7. Are you currently serving as a vehicle maintenance officer or in another position with vehicle maintenance responsibilities? *If you answer No to this question, go directly to question 14. (skip questions 8 through 13)*
1. Yes 2. No
8. Are you subject to vehicle out-of-commission (VOC) standards from your MAJCOM?
1. Yes 2. No

- ### Vehicle Maintenance Performance Measurement Factors

Strongly Disagree Slightly Disagree Disagree Neutral Slightly Agree Agree Strongly Agree

1-----2-----3-----4-----5-----6-----7

- 1 2 3 4 5 6 7

Not At All	Slight Extent	Moderate Extent	Great Extent	Very Great Extent
1	2	3	4	5

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Vehicle Maintenance Performance Measurement Factors (Continued)

To what extent do you believe each of the following independent factors impact the performance level of a vehicle maintenance unit. Please circle your response for each factor.

	Not At All	Slight Extent	Moderate Extent	Great Extent	Very Great Extent
	1-----	2-----	3-----	4-----	5-----
16. Training level of assigned personnel	1	2	3	4	5
17. Experience (# of years) of assigned personnel	1	2	3	4	5
18. Budget available for vehicle maintenance	1	2	3	4	5
19. Age of vehicle fleet	1	2	3	4	5
20. Parts availability	1	2	3	4	5
21. Severity of climate	1	2	3	4	5
22. Availability of warranty service	1	2	3	4	5
23. Age of maintenance facility	1	2	3	4	5
24. Size of maintenance facility	1	2	3	4	5
25. Tool & equipment availability	1	2	3	4	5
26. Forward operating location responsibilities	1	2	3	4	5
27. Vehicle utilization rates	1	2	3	4	5

Identification Of Other Performance Factors

28. If you believe there are other factors that should be considered when determining performance levels of vehicle maintenance units that are not listed above, please list them below.

Appendix F: Performance Measurement Survey Data

555000001001073195001	5326 #0001	34416411251*	54554554234542
555000002001073195001	5326 #0001	3332442 2 2	64445443333444
555000003001073195001	5326 #0001	2221232	53534432322414
555000004001073195001	5326 #0001	2221142	44344343434344
555000005001073195001	5326 #0001	222231222	75554443334555
555000006001073195001	5326 #0001	3332142	74444343433443
555000007001073195001	5326 #0001	3331242	44444442233422
555000008001073195001	5326 #0001	2221432	64453543333434
555000009001073195001	5326 #0001	4332642	54435443222434
555000010001073195001	5326 #0001	3332442	64333433234434
555000011001073195001	5326 #0001	22226327	75545553344544
555000012001073195001	5326 #0001	4341642	75445554323434
555000013001073195001	5326 #0001	3332632	44544332122433
555000014001073195001	5326 #0001	3221242	75544555433444
555000015001073195001	5326 #0001	2232332	75555554333545
555000016001073195001	5326 #0001	332123111141*	64443333222322
555000017001073195001	5326 #0001	2222232	24334332111324
555000018001073195001	5326 #0001	333224222	74533433233324
555000019001073195001	5326 #0001	332123111221*	75555454344554
555000020001073195001	5326 #0001	3332132	65555554455544
555000021001073195001	5326 #0001	4331642	74544553233534
555000022001073195001	5326 #0001	2223632	33454334333344
555000023001073195001	5326 #0001	43326411 211	74543353222333
555000024001073195001	5326 #0001	2332212	55555554344535
555000025001073195001	5326 #0001	3332242	73445353333544
555000026001073195001	5326 #0001	2322212	74522141112412
555000027001073195001	5326 #0001	3232212	75555454355525
555000028001073195001	5326 #0001	2221612	65544343334444
555000029001073195001	5326 #0001	3223322	54444554343545
555000030001073195001	5326 #0001	4332642	24444443322334
555000031001073195001	5326 #0001	3222532	74435454545333
555000032001073195001	5326 #0001	3222222	54335453234423
555000033001073195001	5326 #0001	3332642	64535554334444
555000034001073195001	5326 #0001	2222642	34434343334434
555000035001073195001	5326 #0001	3332132222 2	444443543323433
555000036001073195001	5326 #0001	122112111121163	434553222334
555000037001073195001	5326 #0001	43426312222224444445	4333432
555000038001073195001	5326 #0001	3332642	65545444323424
555000039001073195001	5326 #0001	2221232	74545343344533
555000040001073195001	5326 #0001	3221232222	64444332333334
555000041001073195001	5326 #0001	2221412	64444343233433

Performance Measurement Survey Data (continued)

555000042001073195001	5326 #0001	2222542	65555554445545
555000043001073195001	5326 #0001	2221632	64434342232422
555000044001073195001	5326 #0001	644144122 2	75553345225455
555000045001073195001	5326 #0001	333121112 5	1464554544233423
555000046001073195001	5326 #0001	444214122	75454554234533
555000047001073195001	5326 #0001	3343642	54543354323444
555000048001073195001	5326 #0001	333261222	75445554222453
555000049001073195001	5326 #0001	122113111221*	75545552333525
555000050001073195001	5326 #0001	3332642	65434444234534
555000051001073195001	5326 #0001	3221242	64444554444544
555000052001073195001	5326 #0001	4331242	74554543234545
555000053001073195001	5326 #0001	3333641112211	75344542313411
555000054001073195001	5326 #0001	3332642	75444543233444
555000055001073195001	5326 #0001	3331622	74545555433435
555000056001073195001	5326 #0001	3332612	75555543345554
555000057001073195001	5326 #0001	2233342	64544542133433
555000058001073195001	5326 #0001	3332642	44555454544545
555000059001073195001	5326 #0001	2221232 3	24435353323444
555000060001073195001	5326 #0001	4332632	54444353234434
555000061001073195001	5326 #0001	4332132	64545343343433
555000062001073195001	5326 #0001	4332642	74555453344552
555000063001073195001	5326 #0001	3333642	65545444325445
555000064001073195001	5326 #0001	322134111211*	75555555555555
555000065001073195001	5326 #0001	333243222 211	65433331111123
555000066001073195001	5326 #0001	2221332	65555554334554
555000067001073195001	5326 #0001	2221232	75445553433545
555000068001073195001	5326 #0001	222161111251*	74545454434534
555000069001073195001	5326 #0001	3332242	65444553335544
555000070001073195001	5326 #0001	2333222	75515554112544
555000071001073195001	5326 #0001	2222242	75555554444545
555000072001073195001	5326 #0001	2232132	75555443334435
555000073001073195001	5326 #0001	2222222	65433454233445
555000074001073195001	5326 #0001	2332242	74535553432544
555000075001073195001	5326 #0001	3332442	75555554444544
555000076001073195001	5326 #0001	23323326344 *	63444443343443
555000077001073195001	5326 #0001	433254222 52	75535553234434
555000078001073195001	5326 #0001	644164111151*	75545454323432
555000079001073195001	5326 #0001	3332612	64444443343434
555000080001073195001	5326 #0001	2223342	54555453324534
555000081001073195001	5326 #0001	122112111221*	64525433323332

Performance Measurement Survey Data (continued)

555000082001073195001	5326 #0001	3221642	65555555244555
555000083001073195001	5326 #0001	3332652	55444444344433
555000084001073195001	5326 #0001	622144121252	75445552433435
555000085001073195001	5326 #0001	2221542	64445353333433
555000086001073195001	5326 #0001	2241232	64453453234343
555000087001073195001	5326 #0001	2223642	65554455224433
555000088001073195001	5326 #0001	2223332	64435452223453
555000089001073195001	5326 #0001	122123111252	65555543333534
555000090001073195001	5326 #0001	2221242	*75543354322544
555000091001073195001	5326 #0001	3332612*252	75535454445545
555000092001073195001	5326 #0001	2221232	64555553434533
555000093001073195001	5326 #0001	2332642	65434352233324
555000094001073195001	5326 #0001	666134111221364445343433533	
555000095001073195001	5326 #0001	6444241111 1*	75555453444553
555000096001073195001	5326 #0001	666113111151*	75555453423524
555000097001073195001	5326 #0001	332124211211475444453322433	
555000098001073195001	5326 #0001	2221212	65444232223533
555000099001073195001	5326 #0001	3333612	15555555355434
555000100001073195001	5326 #0001	2222632	65545553434545
555000101001073195001	5326 #0001	333254122	64443342122443
555000102001073195001	5326 #0001	3331112	75555554444545
555000103001073195001	5326 #0001	332114212222245555553343434	
555000104001073195001	5326 #0001	3332642	75555543332353
555000105001073195001	5326 #0001	2332342	75435353233525
555000106001073195001	5326 #0001	3321242	65434343324433
555000107001073195001	5326 #0001	6444241111 1*	75555453444553
555000108001073195001	5326 #0001	666134111221364445343433533	
(Manually Input)		122113111221*	74445443334334
(Manually Input)		33242	64544533344434
(Manually Input)		122113111221*	74445444533443
(Manually Input)		33242	64544533344434

*denotes missing data

Appendix G: Survey Correlation Analysis

14 'VAR' Variables: QUES14 QUES15 QUES16 QUES17 QUES18 QUES19
 QUES20 QUES21 QUES22 QUES23 QUES24 QUES25
 QUES26 QUES27

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
QUES14	112	6.0000	1.2592	672.0	1.0000	7.0000
QUES15	112	4.4286	0.5807	496.0	3.0000	5.0000
QUES16	112	4.4911	0.5850	503.0	3.0000	5.0000
QUES17	112	4.0536	0.8147	454.0	1.0000	5.0000
QUES18	112	4.3839	0.7259	491.0	2.0000	5.0000
QUES19	112	4.1071	0.8736	460.0	1.0000	5.0000
QUES20	112	4.4286	0.6938	496.0	3.0000	5.0000
QUES21	112	3.2679	0.8273	366.0	1.0000	5.0000
QUES22	112	2.8839	0.9177	323.0	1.0000	5.0000
QUES23	112	2.9732	0.8849	333.0	1.0000	5.0000
QUES24	112	3.3661	0.9104	377.0	1.0000	5.0000
QUES25	112	4.2411	0.7503	475.0	1.0000	5.0000
QUES26	112	3.3750	0.9408	378.0	1.0000	5.0000
QUES27	112	3.7411	0.9079	419.0	1.0000	5.0000

Cronbach Coefficient Alpha for RAW variables: 0.842663
 for STANDARDIZED variables: 0.855062

Deleted Variable	Raw Variables		Std. Variables	
	Correlation with Total	Alpha	Correlation with Total	Alpha
QUES14	0.237827	0.858387	0.255550	0.859444
QUES15	0.418987	0.836837	0.415107	0.850548
QUES16	0.467920	0.834719	0.465638	0.847659
QUES17	0.488335	0.832112	0.494091	0.846017
QUES18	0.515865	0.831021	0.521240	0.844440
QUES19	0.507053	0.830843	0.514479	0.844834
QUES20	0.529522	0.830614	0.534215	0.843683
QUES21	0.568915	0.827098	0.576533	0.841197
QUES22	0.521115	0.829889	0.515606	0.844768
QUES23	0.594637	0.824995	0.589491	0.840431
QUES24	0.601292	0.824369	0.603885	0.839577
QUES25	0.605330	0.825783	0.609376	0.839251
QUES26	0.494689	0.831764	0.493101	0.846074
QUES27	0.426081	0.836266	0.435555	0.849383

Correlation Analysis (continued)

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0/ N = 112

	QUES14	QUES15	QUES16	QUES17	QUES18
QUES14	1.00000 0.0	0.32034 0.0006	0.28127 0.0027	0.05269 0.5811	0.12813 0.1782
QUES15	0.32034 0.0006	1.00000 0.0	0.27656 0.0032	0.23667 0.0120	0.24731 0.0086
QUES16	0.28127 0.0027	0.27656 0.0032	1.00000 0.0	0.34123 0.0002	0.27331 0.0035
QUES17	0.05269 0.5811	0.23667 0.0120	0.34123 0.0002	1.00000 0.0	0.19340 0.0410
QUES18	0.12813 0.1782	0.24731 0.0086	0.27331 0.0035	0.19340 0.0410	1.00000 0.0
QUES19	0.17198 0.0698	0.28161 0.0026	0.28392 0.0024	0.32096 0.0006	0.37494 0.0001
QUES20	0.20625 0.0291	0.32265 0.0005	0.23147 0.0141	0.21403 0.0235	0.40376 0.0001
QUES21	0.05189 0.5869	0.26523 0.0047	0.32143 0.0005	0.35279 0.0001	0.26227 0.0052
QUES22	0.14032 0.1400	0.09418 0.3233	0.17424 0.0662	0.33371 0.0003	0.50023 0.0001
QUES23	0.07277 0.4458	0.11020 0.2474	0.26927 0.0041	0.46436 0.0001	0.38080 0.0001
QUES24	0.10217 0.2838	0.29702 0.0015	0.26838 0.0042	0.41060 0.0001	0.31708 0.0007
QUES25	0.27652 0.0032	0.29834 0.0014	0.38463 0.0001	0.34712 0.0002	0.42400 0.0001
QUES26	0.16730 0.0779	0.19789 0.0365	0.23529 0.0125	0.36142 0.0001	0.24899 0.0081
QUES27	0.05516 0.5635	0.28074 0.0027	0.25851 0.0059	0.17726 0.0615	0.24789 0.0084

Correlation Analysis (continued)

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0/ N = 112

	QUES19	QUES20	QUES21	QUES22	QUES23
QUES14	0.17198 0.0698	0.20625 0.0291	0.05189 0.5869	0.14032 0.1400	0.07277 0.4458
QUES15	0.28161 0.0026	0.32265 0.0005	0.26523 0.0047	0.09418 0.3233	0.11020 0.2474
QUES16	0.28392 0.0024	0.23147 0.0141	0.32143 0.0005	0.17424 0.0662	0.26927 0.0041
QUES17	0.32096 0.0006	0.21403 0.0235	0.35279 0.0001	0.33371 0.0003	0.46436 0.0001
QUES18	0.37494 0.0001	0.40376 0.0001	0.26227 0.0052	0.50023 0.0001	0.38080 0.0001
QUES19	1.00000 0.0	0.36948 0.0001	0.38377 0.0001	0.25162 0.0074	0.35336 0.0001
QUES20	0.36948 0.0001	1.00000 0.0	0.44175 0.0001	0.30522 0.0011	0.26833 0.0042
QUES21	0.38377 0.0001	0.44175 0.0001	1.00000 0.0	0.37357 0.0001	0.37909 0.0001
QUES22	0.25162 0.0074	0.30522 0.0011	0.37357 0.0001	1.00000 0.0	0.49533 0.0001
QUES23	0.35336 0.0001	0.26833 0.0042	0.37909 0.0001	0.49533 0.0001	1.00000 0.0
QUES24	0.27875 0.0029	0.29139 0.0018	0.47871 0.0001	0.41794 0.0001	0.63854 0.0001
QUES25	0.31758 0.0006	0.47469 0.0001	0.31594 0.0007	0.32883 0.0004	0.40330 0.0001
QUES26	0.25759 0.0061	0.33125 0.0004	0.42539 0.0001	0.29085 0.0019	0.33681 0.0003
QUES27	0.30790 0.0010	0.23498 0.0126	0.34507 0.0002	0.25554 0.0065	0.31649 0.0007

Correlation Analysis (continued)

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0/ N = 112

	QUES24	QUES25	QUES26	QUES27
QUES14	0.10217 0.2838	0.27652 0.0032	0.16730 0.0779	0.05516 0.5635
QUES15	0.29702 0.0015	0.29834 0.0014	0.19789 0.0365	0.28074 0.0027
QUES16	0.26838 0.0042	0.38463 0.0001	0.23529 0.0125	0.25851 0.0059
QUES17	0.41060 0.0001	0.34712 0.0002	0.36142 0.0001	0.17726 0.0615
QUES18	0.31708 0.0007	0.42400 0.0001	0.24899 0.0081	0.24789 0.0084
QUES19	0.27875 0.0029	0.31758 0.0006	0.25759 0.0061	0.30790 0.0010
QUES20	0.29139 0.0018	0.47469 0.0001	0.33125 0.0004	0.23498 0.0126
QUES21	0.47871 0.0001	0.31594 0.0007	0.42539 0.0001	0.34507 0.0002
QUES22	0.41794 0.0001	0.32883 0.0004	0.29085 0.0019	0.25554 0.0065
QUES23	0.63854 0.0001	0.40330 0.0001	0.33681 0.0003	0.31649 0.0007
QUES24	1.00000 0.0	0.42359 0.0001	0.34317 0.0002	0.32282 0.0005
QUES25	0.42359 0.0001	1.00000 0.0	0.33022 0.0004	0.30406 0.0011
QUES26	0.34317 0.0002	0.33022 0.0004	1.00000 0.0	0.27291 0.0036
QUES27	0.32282 0.0005	0.30406 0.0011	0.27291 0.0036	1.00000 0.0

Appendix H: Detailed Statistical Analysis

<u>Acronym</u>	<u>Question</u>	<u>Acronym</u>	<u>Question</u>	<u>Acronym</u>	<u>Question</u>
VMOEXP	6	VMNOW	7	TRNG	16
MAJVOC	8	BASVOC	9	EXPER	17
DIFVOC	10	CMND	5	BDGT	18
RTE	11	BRFVOC	12	AGE	19
WHOBRF	13	FCTR14	14	PRTS	20
MNPWR	15	DAFS	3	LVL	4
CLMT	21	WRNTY	22	FCAGE	23
FCSZ	24	TL	25	PAFS	2
FOL	26	UTL	27	RNK	1

(STATISTIX 4.0 /// THESIS, 08/13/95, 22:12)

	<u>VMOEXP</u>	<u>VMNOW</u>	<u>MAJVOC</u>	<u>BASVOC</u>	<u>DIFVOC</u>	<u>CMND</u>
N	112	112	36	36	27	112
SUM	354	201	59	54	56	397
MEAN	3.1607	1.7946	1.6389	1.5000	2.0741	3.5446
SD	1.0701	0.4677	1.2907	0.5606	1.0350	1.9447
MINIMUM	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
MEDIAN	3.0000	2.0000	1.0000	1.0000	2.0000	3.0000
MAXIMUM	5.0000	4.0000	7.0000	3.0000	5.0000	6.0000
KURTOSIS	-0.2791	3.4187	9.6195	-0.8430	2.8588	-1.6030

	<u>RTE</u>	<u>BRFVOC</u>	<u>WHOBRF</u>	<u>FCTR14</u>	<u>MNPWR</u>	<u>DAFS</u>
N	26	28	12	111	112	112
SUM	72	39	28	665	498	305
MEAN	2.7692	1.3929	2.3333	5.9910	4.4464	2.7232
SD	1.4229	0.8317	1.2309	1.2613	0.6273	0.8405
MINIMUM	1.0000	1.0000	1.0000	1.0000	3.0000	2.0000
MEDIAN	2.0000	1.0000	2.0000	6.0000	4.0000	3.0000
MAXIMUM	5.0000	5.0000	4.0000	7.0000	7.0000	6.0000
KURTOSIS	-1.0974	10.702	-1.4352	3.1949	1.1936	4.0375

	<u>TRNG</u>	<u>EXPER</u>	<u>BDGT</u>	<u>AGE</u>	<u>PRTS</u>	<u>LVL</u>
N	112	112	112	112	112	112
SUM	503	456	489	460	496	198
MEAN	4.4911	4.0714	4.3661	4.1071	4.4286	1.7679
SD	0.5850	0.8133	0.7352	0.8736	0.6938	0.7825
MINIMUM	3.0000	1.0000	2.0000	1.0000	3.0000	1.0000
MEDIAN	5.0000	4.0000	5.0000	4.0000	5.0000	2.0000
MAXIMUM	5.0000	5.0000	5.0000	5.0000	5.0000	4.0000
KURTOSIS	-0.5577	0.7444	-0.1986	-0.1348	-0.5702	0.4696

	<u>CLMT</u>	<u>WRNTY</u>	<u>FCAGE</u>	<u>FCSZ</u>	<u>TL</u>	<u>PAFS</u>
N	112	112	112	112	112	112
SUM	368	324	332	376	475	305
MEAN	3.2857	2.8929	2.9643	3.3571	4.2411	2.7232
SD	0.8429	0.9139	0.8897	0.9090	0.7503	0.8077
MINIMUM	1.0000	1.0000	1.0000	1.0000	1.0000	2.0000
MEDIAN	3.0000	3.0000	3.0000	3.0000	4.0000	3.0000
MAXIMUM	5.0000	5.0000	5.0000	5.0000	5.0000	6.0000
KURTOSIS	0.0825	-0.1391	-0.1670	-0.2921	1.6184	5.0649

	<u>FOL</u>	<u>UTL</u>	<u>RNK</u>
N	112	112	112
SUM	379	418	323
MEAN	3.3839	3.7321	2.8839
SD	0.9420	0.9102	1.1527
MINIMUM	1.0000	1.0000	1.0000
MEDIAN	3.0000	4.0000	3.0000
MAXIMUM	5.0000	5.0000	6.0000
KURTOSIS	-0.1917	-0.2772	1.5831

BREAKDOWN FOR FCTR14

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
RNK	1	6	39	6.5000	0.5477
RNK	2	38	222	5.8421	1.3661
RNK	3	48	286	5.9583	1.2021
RNK	4	12	71	5.9167	1.6214
RNK	6	8	54	6.7500	0.4629
OVERALL		112	672	6.0000	1.2592

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR FCTR14

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMOEXP	1	15	92	6.1333	1.5523
VMOEXP	2	9	54	6.0000	0.7071
VMOEXP	3	33	190	5.7576	1.4149
VMOEXP	4	53	324	6.1132	1.1546
VMOEXP	5	2	12	6.0000	1.4142
OVERALL		112	672	6.0000	1.2592

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR FCTR14

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMNOW	1	25	162	6.4800	0.7703
VMNOW	2	87	510	5.8621	1.3397
OVERALL		112	672	6.0000	1.2592

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR TRNG

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
RNK	1	6	27	4.5000	0.5477
RNK	2	38	171	4.5000	0.6040
RNK	3	48	214	4.4583	0.6174
RNK	4	12	54	4.5000	0.5222
RNK	6	8	37	4.6250	0.5175
OVERALL		112	503	4.4911	0.5850

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR PRTS

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
RNK	1	6	25	4.1667	0.7528
RNK	2	38	170	4.4737	0.6872
RNK	3	48	208	4.3333	0.7532
RNK	4	12	56	4.6667	0.4924
RNK	6	8	37	4.6250	0.5175
OVERALL		112	496	4.4286	0.6938

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR MNPWR

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
RNK	1	6	25	4.1667	0.7528
RNK	2	38	167	4.3947	0.6384
RNK	3	48	215	4.4792	0.5454
RNK	4	12	51	4.2500	0.4423
RNK	6	8	38	4.7500	0.4629
OVERALL		112	496	4.4286	0.5827

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR BDGT

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
RNK	1	6	29	4.8333	0.4082
RNK	2	38	165	4.3421	0.7807
RNK	3	48	207	4.3125	0.7192
RNK	4	12	50	4.1667	0.7177
RNK	6	8	38	4.7500	0.7071
OVERALL		112	489	4.3661	0.7352

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR TL

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
RNK	1	6	23	3.8333	0.9832
RNK	2	38	165	4.3421	0.7081
RNK	3	48	200	4.1667	0.7810
RNK	4	12	50	4.1667	0.7177
RNK	6	8	37	4.6250	0.5175
OVERALL		112	475	4.2411	0.7503

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR AGE

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
RNK	1	6	27	4.5000	0.5477
RNK	2	38	147	3.8684	1.0180
RNK	3	48	206	4.2917	0.7707
RNK	4	12	50	4.1667	0.8348
RNK	6	8	30	3.7500	0.7071
OVERALL		112	460	4.1071	0.8736

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR EXPER

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
RNK	1	6	22	3.6667	1.0328
RNK	2	38	150	3.9474	0.9850
RNK	3	48	197	4.1042	0.6916
RNK	4	12	51	4.2500	0.6216
RNK	6	8	36	4.5000	0.5345
OVERALL		112	456	4.0714	0.8133

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR TRNG

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMNOW	1	25	113	4.5200	0.5859
VMNOW	2	87	390	4.4828	0.5879
OVERALL		112	503	4.4911	0.5850

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR PRTS

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMNOW	1	25	112	4.4800	0.6532
VMNOW	2	87	384	4.4138	0.7080
OVERALL		112	496	4.4286	0.6938

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR MNPWR

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMNOW	1	25	111	4.4400	0.5831
VMNOW	2	87	385	4.4253	0.5833
OVERALL		112	496	4.4286	0.5807

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR BDGT

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMNOW	1	25	111	4.4400	0.7681
VMNOW	2	87	378	4.3448	0.7286
OVERALL		112	489	4.3661	0.7352

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR TL

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMNOW	1	25	107	4.2800	0.7916
VMNOW	2	87	368	4.2299	0.7424
OVERALL		112	475	4.2411	0.7503

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR AGE

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMNOW	1	25	103	4.1200	0.7810
VMNOW	2	87	357	4.1034	0.9026
OVERALL		112	460	4.1071	0.8736

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR EXPER

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMNOW	1	25	107	4.2800	0.7371
VMNOW	2	87	349	4.0115	0.8282
OVERALL		112	456	4.0714	0.8133

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR TRNG

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMOEXP	1	15	71	4.7333	0.4577
VMOEXP	2	9	40	4.4444	0.7265
VMOEXP	3	35	155	4.4286	0.5576
VMOEXP	4	53	237	4.4717	0.6078
OVERALL		112	503	4.4911	0.5850

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR PRTS

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMOEXP	1	15	66	4.4000	0.6325
VMOEXP	2	9	39	4.3333	1.0000
VMOEXP	3	35	150	4.2857	0.7886
VMOEXP	4	53	241	4.5472	0.5740
OVERALL		112	496	4.4286	0.6938

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR MNPWR

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMOEXP	1	15	70	4.6667	0.4880
VMOEXP	2	9	37	4.1111	0.6009
VMOEXP	3	35	151	4.3143	0.6311
VMOEXP	4	53	238	4.4906	0.5415
OVERALL		112	498	4.4464	0.6273

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR BDGT

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMOEXP	1	15	66	4.4000	0.8281
VMOEXP	2	9	39	4.3333	0.7071
VMOEXP	3	35	153	4.3714	0.7702
VMOEXP	4	53	231	4.3585	0.7097
OVERALL		112	489	4.3661	0.7352

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR TL

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMOEXP	1	15	68	4.5333	0.5164
VMOEXP	2	9	36	4.0000	0.7071
VMOEXP	3	35	142	4.0571	0.9056
VMOEXP	4	53	229	4.3208	0.6729
OVERALL		112	475	4.2411	0.7503

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR AGE

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMOEXP	1	15	59	3.9333	1.2228
VMOEXP	2	9	42	4.6667	0.5000
VMOEXP	3	35	141	4.0286	0.8220
VMOEXP	4	53	218	4.1132	0.8242
OVERALL		112	460	4.1071	0.8736

CASES INCLUDED 112 MISSING CASES 0

BREAKDOWN FOR EXPER

VARIABLE	LEVEL	N	SUM	MEAN	S.D.
VMOEXP	1	15	64	4.2667	0.8837
VMOEXP	2	9	28	3.1111	1.0541
VMOEXP	3	35	145	4.1429	0.7334
VMOEXP	4	53	219	4.1321	0.7081
OVERALL		112	456	4.0714	0.8133

CASES INCLUDED 112 MISSING CASES 0

RANK SUM TWO-SAMPLE TEST FOR AGE BY O3/OTHER

O3/OTHER	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
1	2213.00	46	1132.00	48.1
2	4115.00	66	1904.00	62.3
TOTAL	6328.00	112		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION (z-statistic): 2.280
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.0226

RANK SUM TWO-SAMPLE TEST FOR AGE BY ZERO YEARS EXPERIENCE

ZERO YEARS	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
1	911.00	16	775.00	56.9
2	5417.00	96	761.00	56.4
TOTAL	6328.0	112		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION (z-statistic): 0.054
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.9569

RANK SUM TWO-SAMPLE TEST FOR EXPERIENCE BY LESS THAN ONE YEAR EXPERIENCE

LESS ONE	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
1	247.50	9	202.50	27.5
2	6080.50	103	724.50	59.0
TOTAL	6328.00	112		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION (z-statistic): 2.788
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.0053

RANK SUM TWO-SAMPLE TEST FOR TOOLS BY 0-1 THRU 0-2

LESS ONE	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
1	249.00	6	228.00	41.5
2	6079.00	106	408.00	57.3
TOTAL	6328.00	112		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION (z-statistic): 1.157
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.2475

RANK SUM TWO-SAMPLE TEST FOR EXPERIENCE BY 01/02/03

01/02/03	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
1	2291.00	44	1301.00	52.1
2	4037.00	68	1691.00	59.4
TOTAL	6328.00	112		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION (z-statistic): 1.159
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.2466

RANK SUM TWO-SAMPLE TEST FOR QUESTION 14 BY 1-LESS THAN TWO

1-LESS-TWO	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
1	1788.00	35	1158.00	51.1
2	4540.00	77	1537.00	59.0
TOTAL	6328.00	112		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION (z-statistic): 1.186
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.2355

RANK SUM TWO-SAMPLE TEST FOR QUESTION 14 BY VMONOW

VMONOW	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
1	1719.5	25	1394.50	68.8
2	4608.5	87	780.50	53.0
TOTAL	6328.0	112		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION (z-statistic): 2.142
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.0322

RANK SUM TWO-SAMPLE TEST FOR QUESTION 14 BY 0-1/0-2/OTHER

0-1/0-2/OTHER	RANK SUM	SAMPLE SIZE	U STAT	MEAN RANK
1	1023.5	14	918.50	73.1
2	5304.5	98	453.50	54.1
TOTAL	6328.0	112		

NORMAL APPROXIMATION WITH CONTINUITY CORRECTION (z-statistic): 2.041
TWO-TAILED P-VALUE FOR NORMAL APPROXIMATION: 0.0412

Appendix I: Demographic Data

1. What is your present rank?

0-1 thru 0-2	6	5.4%
0-3	38	33.9%
0-4	48	42.9%
0-5	12	10.7%
0-6	0	0%
Other	8	7.1%

2. What is your primary AFSC?

24T1	0	0%
24T3	47	42%
24T4	56	50%
Other	9	8%

3. What is your duty AFSC?

24T1	0	0%
24T3	50	44.6%
24T4	49	43.8%
Other	13	11.6%

4. At what organizational level are you currently performing your duties?

Base/Wing-Level	46	41.1%
Staff-Level	51	45.5%
Other	15	13.4%

5. To which command are you assigned?

ACC	15	13.4%
AMC	35	31.3%
AFMC	12	10.7%
PACAF	8	7.1%
USAFE	5	4.5%
Other	37	33.0%

6. How much experience have you had as a vehicle maintenance officer?

None	15	13.4%
Less than 1 year	7	6.3%
1 but less than 2 years	35	31.3%
2 years or more	55	49.1%

7. Are you currently serving as a vehicle maintenance officer or in another position with vehicle maintenance responsibilities?

Yes	27	24.1%
No	85	75.9%

8. Are you subject to vehicle out-of-commission (VOC) standards from your MAJCOM?

Yes	23	63.9%
No	13	36.1%

9. Are you subject to VOC standards from your base or unit?

Yes	20	55.6%
No	16	44.4%

10. If you answered yes to question 9, are these standards different from your MAJCOM standard?

Yes	7	26.9%
No	19	73.1%

11. If you are subject to VOC standards, what is your current standard?

More than 10%	3	11.1%
10%	14	51.9%
9%	1	3.7%
8%	2	7.4%
Other	7	25.9%

12. Are you required to brief or report your VOC results on a regular basis?

Yes	20	71.4%
No	8	28.6%

13. If you answered yes to question 12, who is briefed about your VOC rates (*mark all that apply*)?

MAJCOM	14	77.7%
Wing Level	12	66.6%
Group Level	11	61.1%
Unit Level	14	77.7%

(10/18 respondents briefed all 4 levels/55.5%)

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE September 1995		3. REPORT TYPE AND DATES COVERED Master's Thesis	
4. TITLE AND SUBTITLE EVALUATION OF THE VEHICLE OUT-OF-COMMISSION STANDARD FOR AIR FORCE VEHICLE MAINTENANCE UNITS				5. FUNDING NUMBERS	
6. AUTHOR(S) Christopher K. Arzberger, Captain, USAF Lawrence F. Audet, Jr., Captain, USAF					
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Institute of Technology, WPAFB OH 45433-7765				8. PERFORMING ORGANIZATION REPORT NUMBER AFIT/GTM/LSM/95S-2	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) HQ PACAF/LGT Hickam AFB, HI 96853-5427				10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES					
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited				12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) Because the Department of Defense is facing budget and manpower reductions, the importance of productivity, efficiency, and effectiveness in daily operations is being stressed. Unfortunately, the VOC performance measure does not adequately apply these concepts. By examining the concepts of productivity, efficiency, and effectiveness, the inadequacy of the VOC measure is highlighted. A review of research into performance measurement is conducted, with emphasis on USAF transportation squadrons, to examine perceptions about the VOC measure. Because the VOC measure is viewed as inadequate, a review of performance measurement indicators throughout the government is analyzed to determine the type of performance measurement system that should be used for vehicle maintenance units. The use of linear regression is advocated. This research also identifies the seven independent factors perceived by transportation officers as impacting the performance of vehicle maintenance the most. These factors include training levels of assigned personnel, parts availability, available manpower, budget available for vehicle maintenance, tool and equipment availability, age of vehicle fleet, and experience (# of years) of assigned personnel and should be included in a regression model to accurately establish and compare the performance levels of vehicle maintenance units.					
14. SUBJECT TERMS Vehicle Maintenance, Vehicle Out-Of-Commission Standard, Performance Measurement, Systems, Performance Standards, Productivity, Efficiency, Effectiveness.				15. NUMBER OF PAGES 126	
				16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL		